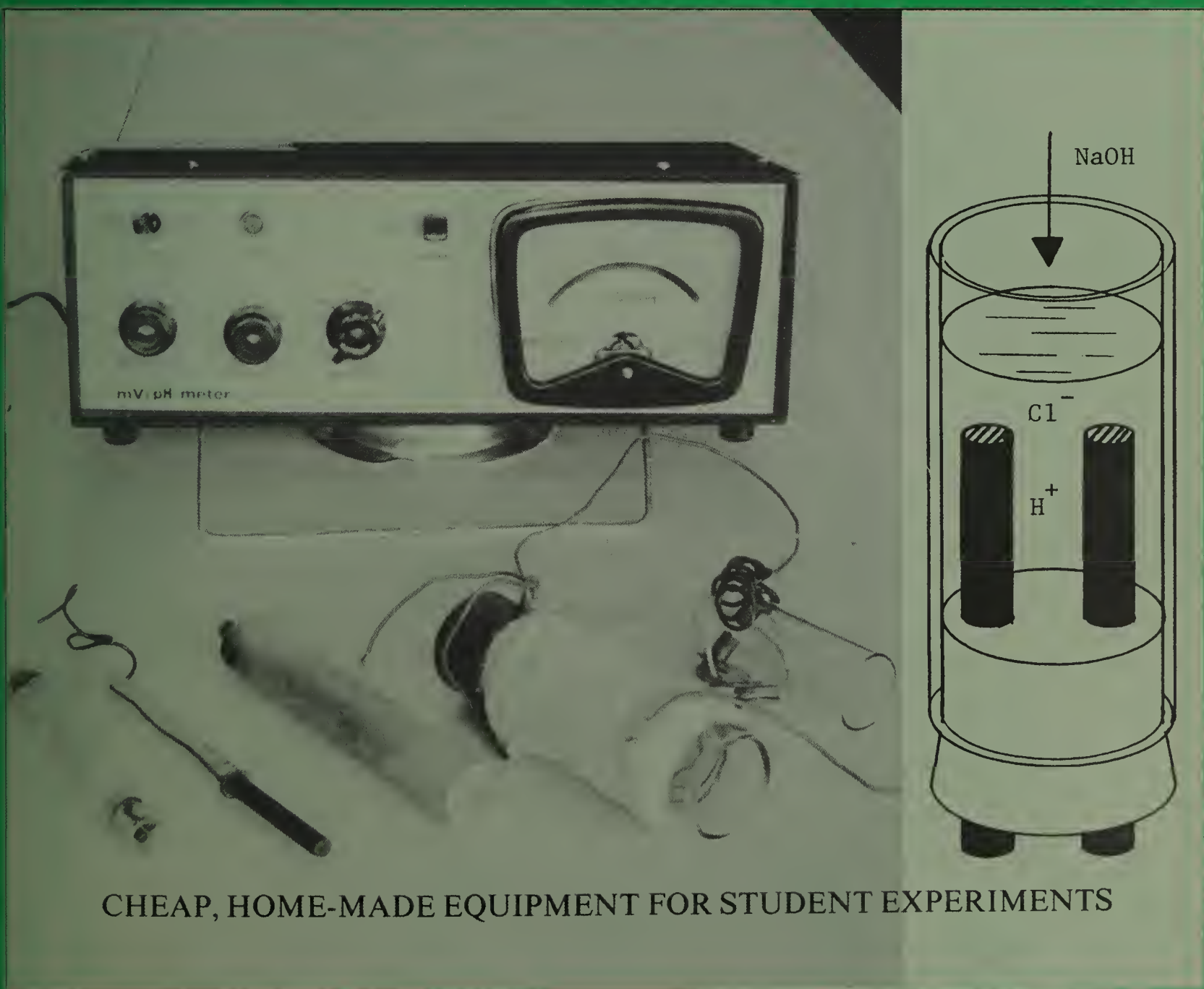


Chemistry International

The news magazine of the International Union
of Pure and Applied Chemistry (IUPAC)



The photograph on the left shows a rectangular electronic device labeled "mV/pH meter" with a large analog scale and three input ports. It is connected to various electrodes and wires. The schematic diagram on the right depicts a cylindrical container with two electrodes. The left electrode is labeled Cl^- and the right electrode is labeled H^+ . An arrow labeled "NaOH" points into the top of the container, indicating the addition of sodium hydroxide.

CHEAP, HOME-MADE EQUIPMENT FOR STUDENT EXPERIMENTS

CHEMISTRY INTERNATIONAL

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of Pure and Applied Chemistry (IUPAC)

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THE EDITOR'S DESK

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Speak, and be heard

English has become the universally-accepted language at scientific meetings and international conferences. Although nearly all chemists now learn to *read* English, many have little experience with *spoken* English. It is unavoidable that they encounter some difficulty communicating with other chemists at international meetings; but this problem could be largely eliminated—if only it were recognized. Unfortunately, speakers from English-speaking countries often take for granted the privilege of using their native language.

Anyone who has attended a scientific conference has encountered "the Mumbler", the speaker whose voice fades to nothing at the critical part of a sentence. At nearly every conference, there is "the Racer", the lecturer who chatters at a furious pace to present far more material than could possibly be covered in the allotted time. Then, there is the notorious "Droner", the scientist who uses complicated words because (he thinks) it makes him sound distinguished. Everyone recognizes that such blatant abuse of language detracts from the value of a conference. However, many scientists do not realise that *they* sometimes slurr their words, talk too fast, or use terms that are not familiar. These habits generally pose only minor inconvenience to those speaking the same language, but create serious problems for those who do not. Many conference participants from non-English-speaking countries have difficulty understanding what other speakers have said, are afraid to participate, and feel excluded from the discussion around them.

The extent of this problem is not realised, Dr. Reinhard Marcuse stated to me during a discussion at the IUPAC General Assembly. At many international meetings he had attended, speakers paid little attention to the linguistic difficulties of chemists from non-English-speaking countries. It is not reasonable, he asserted, for speakers to expect participants at an international meeting to have mastery of English. In return for the privilege of using their native language, English-speaking participants should make a special effort to speak clearly. The Chairman of each session or meeting should ensure that they do.

IUPAC is ideally placed, in the view of Dr. Marcuse, to do something about this pervasive communication barrier. He noted that IUPAC has suggested common-sense guidelines for chemists to write articles and prepare lecture slides (see *Chemistry International*, Issue Nos. 2 & 3, 1981). Why not encourage conference lecturers to speak so that their findings can be understood by everyone present? This practice would make for better lectures and more valuable discussion for everyone. In every lecture room at international meetings, he proposed, a large poster would be prominently displayed, instructing all speakers to talk **slowly, clearly and simply.**

Microbiologists discover that bacteria have remarkable ability to adapt, cooperate—and even change lifestyle

The development of modern microbiology stemmed from the pioneering efforts of Robert Koch who, one hundred years ago, reported his technique for isolating and culturing bacteria. By streaking suspensions of bacteria across the surface of a nutrient medium that had been solidified with gelatin, Koch was able for the first time to prepare colonies of single bacterial species (monocultures) and study their properties. More than any other development, Koch's work steered the advancement of microbiology up to the present time.

The course charted by Koch, as it is becoming increasingly apparent, has led microbiologists to a very limited view of how microorganisms really live. Conditions commonly used to culture bacteria in the laboratory and industrial fermentations, where the bacteria are continuously provided with an abundant supply of a few essential nutrients, are almost never encountered in nature. The artificial conditions maintained in these simplistic monoculture experiments have led to the impression that bacteria are passive organisms that simply multiply or die in response to changes in their environment. What has become clear in recent years is that bacteria can actively interact with their environment—exhibiting a surprising degree of adaptability.

In natural environments, bacteria live in complex communities with viruses, fungi and other bacteria with which they cooperate or compete. The limited supply of nutrients, normally found in the natural environment, fosters development of complex relationships between different microorganisms that enables them to survive. To obtain carbon and energy for growth, each species may need to metabolize a wide range of compounds. Bacteria may rely on other microorganisms to produce nutrients from complex undigestible compounds, or to utilize and eliminate metabolic waste products.

A recent trend in microbiology is towards experiments which more closely simulate conditions in nature. These experiments—employing a mixture of nutrients, several species of microorganisms, and environmental conditions that vary with time and position—are opening new dimensions for research in microbiology and biotechnology. Some of the most recent and exciting developments were described at a

Royal Society Discussion Meeting, *New Dimensions in Microbiology: Mixed Substrates, Mixed Cultures and Microbial Communities*, held in London (the UK) on 11 - 12 November 1981. That meeting paid tribute to Koch's great contribution, noting that the development of monoculture techniques was an essential stepping stone for the advancement of microbiology. It was, however, a stepping stone on which microbiologists may have paused too long, and researchers are now seeking new ground on which to venture.

Bacteria living in simple laboratory cultures develop different biochemical pathways than those utilized by bacteria in the natural environment, as shown by Prof. W. Harder (of the State University of Groningen in the Netherlands). Under normal laboratory conditions, when bacteria are provided with high concentrations of a few substrate (nutrient) compounds, they preferentially utilize *one* substrate. Only after this substrate has been consumed will the bacteria begin to produce enzymes needed to metabolize other compounds. It is rare, with conditions normally used in laboratory cultures, to find two substrates being consumed simultaneously. Not so in most natural environments, where competition for nutrients demands that bacteria cannot be so fastidious in their diet. With nutrients available in limited amounts, bacteria are generally able to metabolize several substrates. To do so, they develop several independent biochemical pathways. The amount of cell mass produced by growth in a complex nutrient medium is simply the sum of all cell masses that would be produced if each nutrient alone were present.

Characteristics which are necessary for survival in the natural environment contrast sharply with those selected by man. Indeed, the very process of isolating one bacterial species in laboratory cultures discriminates against "generalist bacteria" that can utilize a wide range of nutrients and adapt to a wide range of conditions. Continuous supply of a culture broth containing high concentrations of one substrate favours the growth of "specialist bacteria" that can best utilize this substrate. "Generalist" bacteria cannot grow as quickly, and their numbers dwindle in continuous cell

culture (since they are swept out of the fermenter at a rate faster than they can multiply). Although many of these highly-adaptable organisms have never been isolated by microbiologists, they are often the most abundant and successful species found in soil and water.

The same ability to adapt is found in bacteria that produce nutrients by photosynthesis. They alter their biochemical processes in response to the amount of light available, its spectral characteristics, and other environmental conditions. Professor M. Shilo (of the Hebrew University of Jerusalem, Israel) explained that it is not unusual for bacteria to form clearly defined layers at the surface of a lake; bacteria in each layer synthesize pigments which absorb light wavelengths not utilized by the overlying layers. In fact, he noted, a bacterium can vary the amount of pigment it produces—or even produce different pigments—to make most efficient use of available light. This he demonstrated convincingly with a slide showing three flasks containing the same bacterial species which had been exposed to light of different colours. The bacteria exposed to white light synthesized two pigments (one absorbing blue light, the other absorbing red), as was apparent from the green colour of the bacterial cell suspension. In the other two flasks, which had been exposed to blue and red light respectively, the bacteria synthesized only the pigment which absorbed the colour of its light source.

Photosynthetic bacteria adapt two different strategies for survival. Some drift freely in solution, using flagella (long, whip-like appendages) or inflatable gas vacuoles to move to an optimum position in the light beam. A second type, on which Prof. Shilo focussed his attention, adhere to suspended particles, sediments or the surface of rocks. These organisms cling so tenaciously to the underlying surface that they are not detached by very rapid and turbulent streams of water. Yet, such bacteria can evidently move rapidly when fresh sediment is deposited, blocking the incident light. Even more surprising is their ability to spread to other surfaces in the aquatic environment. How can such bacteria become dispersed if they adhere so strongly to solid particles? In all such organisms that have been studied, Prof. Shilo explained, the life cycle includes a phase in which the bacteria migrate freely in solution. The properties of bacteria in the two phases are entirely different. Because bacteria in the dispersed phase are always hydrophilic, while bacteria in the adherent phase are hydrophobic, Prof. Shilo could easily separate the two phases in an aqueous suspension of bacteria by adding an organic solvent. Bacterial cells in the adherent phase were extracted into the decane (as could be seen immediately by its colour), while other cells remained suspended in the water layer.

The ability of photosynthetic bacteria to

adapt rapidly to environmental changes might best be illustrated by the recent discovery of a new type of photosynthetic organism living in salt marshes, mangroves and rice paddies. In this environment, oxygen levels fluctuate dramatically, swinging from near zero up to very high concentrations. At the same time, rapid changes occur in acidity and sulfide ion concentration. Previously, it had been thought that bacteria found in anaerobic environments could not survive exposure to oxygen, and that aerobic bacteria would not tolerate absence of oxygen.

Perhaps the most remarkable aspect of how bacteria respond to their environment is how they interact with other bacteria and viruses. Although bacteria have generally been studied as isolated species, they almost always live in complex microorganism communities in the natural environment. One natural environment of great importance is the surface of mucous membranes in animals and man, where most infectious diseases enter the body.

One of the main protective elements that prevents entry of disease-producing bacteria is the population of bacteria that normally live on mucous membranes. It is not well understood whether these innocuous microorganisms protect their host by competing against invading pathogens for oxygen, nutrients or free surface on which to adhere (similar to the way in which a cluster of regular drinkers may block visitors trying to reach the bar). There is some evidence that indigenous bacteria also produce bacteriostatic compounds which inhibit the growth of invading organisms. The extent of each of these protective mechanisms has not been established, nor is it understood why indigenous bacteria do not provide complete protection against pathogenic microbes. What is clear, as Professor Harry Smith (University of Birmingham, UK) emphasized, is that indigenous bacteria *do* provide some protection against infectious diseases. It might even prove practical to exploit this protection by deliberately inoculating new-born animals with the microorganisms that normally become established on their mucous membranes.

It is also known that pathogens do not always act independently. Viruses may exacerbate the effect of bacterial infections by allowing invading bacteria to penetrate mucous membranes, and by reducing the ability of white blood cells to destroy the invading organisms. Among the numerous examples where such an effect has been observed is the increase in severity of staphylococcal infections in people suffering from influenza.

In order for a pathogen to infect a host animal, it must adhere to the surface of mucous membranes, enter the host, multiply in the animal's body, and interfere with the body's normal defense systems. Sometimes, a group of microorganisms can provide the full complement of factors for disease production, while

each member of the group cannot. In these cases, a group of harmless or weakly pathogenic organisms can act together to produce a serious disease. One example is heel abscess in sheep, caused by two microorganisms. One provides a growth stimulant for the second which, in turn, inhibits destruction of the first by white blood cells. Either organism, by itself, does not induce symptoms of the disease. Another example is calf pneumonia, for which the pathogen is a community of 2 viruses, 3 fungi and several types of bacteria.

From this and other recent evidence, it seems that bacteria are much more complicated organisms than had previously been suspected, cooperating or competing with other members of its own species and other microorganisms. Microbes, like people, are mutually dependent on each other. They interact in ways that are not fully understood or recognized. Microbial communities can even be compared with human society, as one conference speaker alluded when he remarked that "no bacterium is an island" in its relations with other living things.

Work should not be sole interest and source of self-esteem, psychiatrist warns

Regardless of whether a chemist works in industry, a university or government laboratory, he/she will at some time be subjected to stress, disappointment, or even failure. Some people cope well, continuing to be optimistic about their work and providing encouragement to their colleagues or students. Others don't. What is the source of inner strength that allows some people to cope with difficult situations, and bounce back on their feet?

To find out, psychiatrist Dr. Merville Vincent considered the effect of stress on medical practitioners, and how some cope with stress much better than others. Medical doctors face pressures that far exceed the responsibilities imposed on other professionals. This stress imposes a heavy toll on the health and well-being of medical doctors. In some countries, medical doctors have the highest suicide rate of all professional groups. Work-related stress also manifests itself in fatigue, depression, marital breakdown, and alcohol or drug abuse.

Work-related stress encountered by the chemist or chemical educator is usually much less severe than the demands of medical practice. Nonetheless, Dr. Vincent's conclusions and recommendations would probably apply equally well to professional chemists.

Individuals who cannot cope with problems at work, Dr. Vincent observed, are those who neglect their personal priorities, and come to rely almost entirely on their profession for esteem and security. "It is hazardous to put all your eggs in the basket of professional esteem", he writes (in *Annals of the Royal College of Physicians and Surgeons of Canada*, July 1981, pp. 277 - 281). "There is danger in having only patients to give us security and esteem" (the same might apply to students).

When things don't go well at work, and the confidence of the doctor or chemist is shaken, he needs other interests and sources of emotional support.

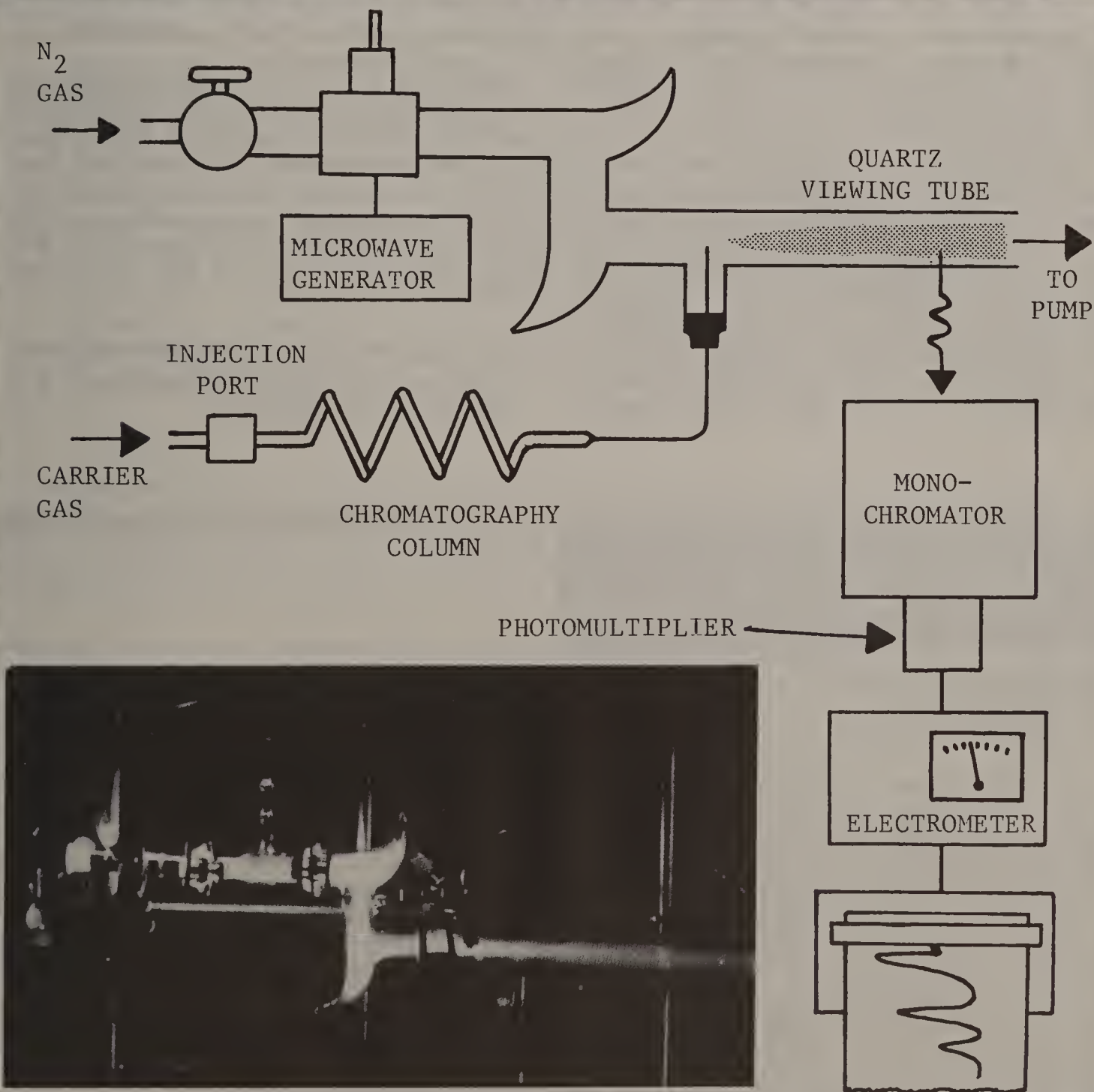
Many professionals become so involved in their work that little time and energy are left over for their families and outside interests. Enduring, meaningful relationships with one's wife and children don't just happen, Dr. Vincent states, but come about because the individual arranged his priorities so that time could be devoted to his spouse and children regularly through the years. Of course, time is exactly what most doctors (and most researchers and educators) lack. "Many physicians start out with good intentions of spending time with their wives and families", he explains, "but . . . after many years of marriage, the physician finds that the urgencies of practice have replaced the routine of marriage and family".

Dr. Vincent describes how many doctors in their 40s become cynical about their profession, about life and about patients with unreasonable demands. Cynicism, he believes, is a defense against despair, and is most commonly encountered in those individuals who work themselves into physical and emotional fatigue. These doctors are overcommitted to work, and have not established their priorities to allow time for self-renewal. By providing time for friends, for family vacations, for recreation, and even some time to do nothing, the professional has the opportunity to regain perspective, humour, patience, and emotional and physical strength. Relationships and interests outside his work assures the individual of his value as a person. It provides the professional with a meaning and philosophy of life that prevents him from becoming engulfed by the stress or problems of the job.

Trace compounds in gases are detected by selective excitation with N_2^*

A simple and relatively inexpensive technique for measuring trace concentrations of volatile compounds, described at the IUPAC Congress by Dr. David Sutton*, utilizes the unusual stability of excited nitrogen molecules. The technique, called "Metastable Transfer Emission Spectrometry" (MTES), might prove especially useful as a selective detector for gas chromatography, although it can be utilized to analyze any material which can be vapourized.

In his poster presentation, Dr. Sutton described how a microwave discharge in a stream of nitrogen gas produces electronically and vibrationally-excited N_2^* molecules. These metastable molecules retain their excitation energy and are carried along with the gas stream. Only when they come into contact with other molecules, can metastable nitrogen molecules transfer their excitation energy. A sample molecule absorbing this energy



The METS chromatography detector responds specifically to hydrocarbons, or several other classes of compounds (see table). It utilizes the production of long-lived excited nitrogen molecules in a microwave discharge. Downstream, gases leaving a chromatography column are metered into the flow of excited nitrogen through a thin capillary tube. When hydrocarbons are eluted from the chromatography column, they react with excited nitrogen molecules to produce CN fragments. Light is emitted by the excited fragments at a wavelength of 385 nm, causing the afterglow in the quartz viewing tube to turn blue. Light emission at this wavelength is transmitted through a monochromator to a photomultiplier. The resulting photocurrent is proportional to the amount of hydrocarbon being eluted from the chromatography column (*photograph courtesy of Dr. D. G. Sutton*).

Sample compound	Example	Fluorescing species	Emission wavelength (nm)
Atoms	Pb	Pb	283
Metal hydrides	GeH ₄	Ge	265
Metal alkyls	Al(CH ₃) ₃	Al, CN	296, 385
Phosphorus compounds	PH ₃	PN	252
Hydrocarbons	C ₂ H ₄	CN	385
Alcohols	R-OH	OH	302
Ketones	R-CO-R	NO	235

dissociates into excited fragments, which radiate energy at a characteristic wavelength (for one compound, NO, the sample molecule radiates the excitation energy directly, without dissociating).

The intensity of fluorescence emitted by a particular compound is proportional to its concentration in the sample vapour, so that the actual concentration of the compound can be determined by measuring its fluorescence. The technique is selective, and can distinguish fluorescence emitted by different types of compounds. By using a monochromator or interference filter to transmit radiation within a selected band of wavelength, the light detector

will respond only to radiation emitted by a certain class of compounds.

Metastable Transfer Emission Spectrometry is a particularly sensitive method for measuring concentrations of atoms in a gas stream, responding to as little as 10^4 atoms/cm³. Sensitivity is somewhat less for molecules. Nonetheless, quantitative measurements can be made over the concentration range of 10^6 - 10^{12} molecules/cm³ (0.3 ppb - 30 ppm in the gas mixture).

** Dr. Sutton has undertaken his development project at Aerospace Corporation in Los Angeles, California (USA).*

LETTER

Wrong origin cited for Asian network

I would like to correct some erroneous information given in your article "Chemistry will be the Driving Force Accelerating the Development of Asia" *Chemistry International*, No. 4, August 1981, pp. 14 - 20). I refer to Mr. Hugh Grayson's comment on what is termed "the recently-formed Southeast Asian Network for the Chemistry of Natural Products." According to your report (p. 17, col. 2) the "network grew from the personal contact of an Australian chemistry professor (Prof. Jack Cannon) with his former doctoral student (Phichai Tovivich). That relationship expanded to encompass chemists in ten Asian countries involved with research on natural

products".

The fact of the matter is that the Network started operations in 1976 as a result of an initiative by Unesco and the Government of Japan in 1974. The initiative had nothing to do either with myself or, as far as I know, with Professor Cannon. Certainly it had nothing to do with our mutual association. The first executive secretary was Dr. Sunt Techakumpuch and the first representative for Australia was Professor A. J. Birch of the Australian National University, Canberra. Also, although I would have been honoured in the event, unfortunately I have never been a student of Professor Cannon.

Dr. P. Tovivich, Executive Secretary
Southeast Asian Network for the
Chemistry of Natural Products

Home-made chemical instruments upgrade laboratory training at low cost

The rising cost of equipment and chemicals is imposing increasing financial pressure for chemical educators to restrict laboratory training. In India, for example, the price of chemical glassware increased by nearly 60% between 1979 and 1981, while many chemicals doubled in price. During the same period, laboratory funding has essentially remained static. Basic chemical instrumentation has become so expensive as to preclude its use in many courses. If this trend continues, students might not acquire any experience with modern chemical techniques. There is a real danger that, in developing countries, chemistry will deteriorate into a lecture-room science, even when there is a genuine commitment to laboratory training. Already, laboratory experiments are selected largely on the basis of the equipment available, rather than the requirements of the curriculum.

One option to circumvent the rising costs of chemical instrumentation is for chemistry departments to assemble their own. A group from Delhi University has demonstrated that pH meters, millivolt meters and conductance meters can be built with locally-available components at less than one-tenth the cost of commercial units. They have also shown that these instruments can be utilized to perform a wide range of chemical analyses and laboratory measurements. In these experiments, the home-made instruments provided results that were indistinguishable from those of commercial models.

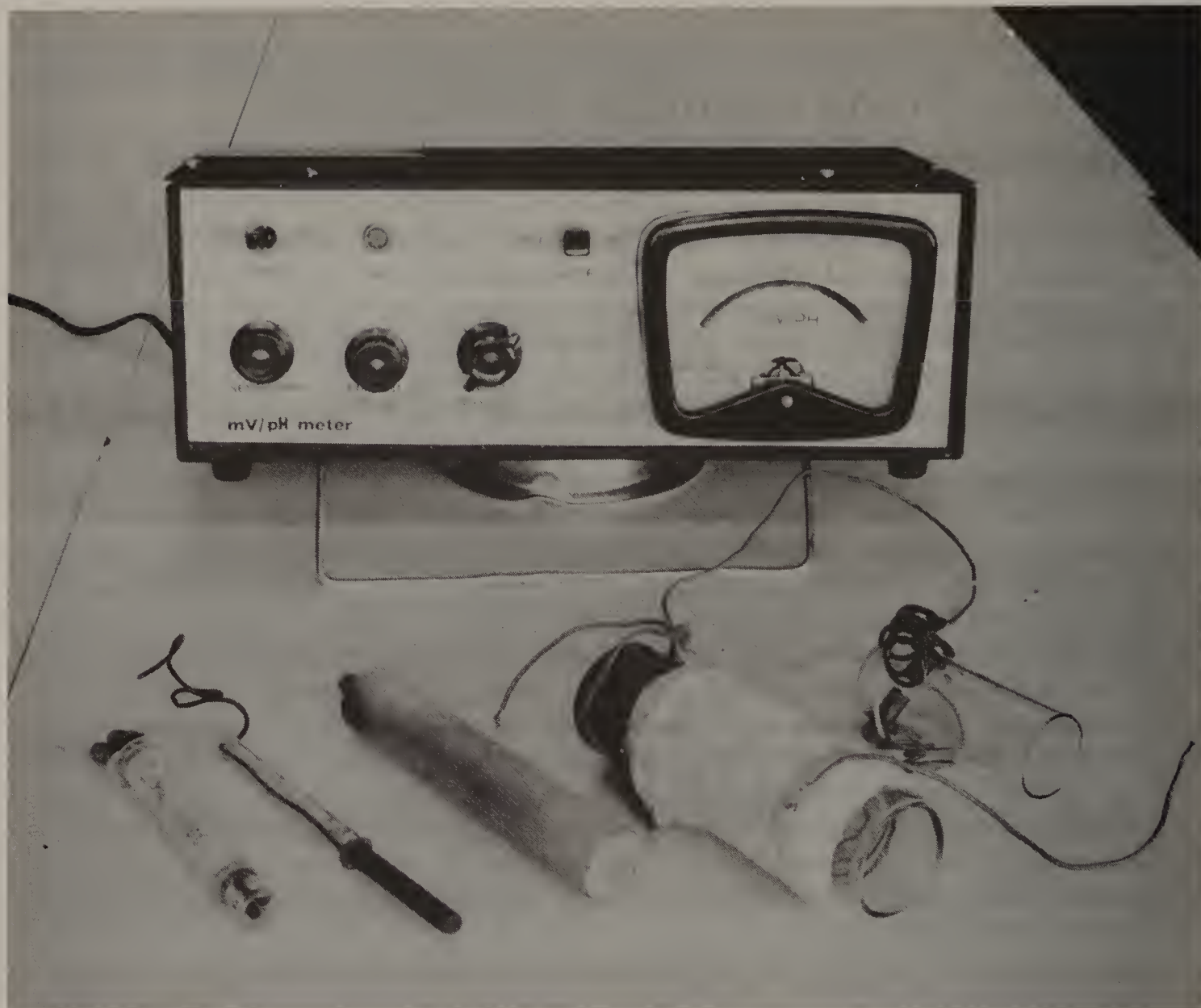
Designing and building chemical instruments may sound like an awesome undertaking to many chemists. However, major advances in electronics during the last decade have considerably *simplified* the design of instruments. Complicated functions can now be performed by integrated circuit "chips". Although these miniature components may each contain hundreds of transistor and resistors, the instrument designer need not know anything about their intricate internal circuitry. He need only ensure that the power supply voltage is applied to the correct terminals, that the signal applied to the input terminal has the desired characteristics, and that the signal appearing on the output terminal is correctly utilized.

Especially versatile is the operational amplifier, or "opamp". The characteristics of operational amplifiers make them ideal for the design of simple circuits. This one component can amplify very small electrical signals, providing an output voltage up to 100 million times greater than the input voltage. It can deliver enough output current to operate a meter, yet draws only a miniscule current into the input terminal (it therefore does not polarize or "load down" the electrochemical cell whose voltage is being measured). Operational amplifiers can perform almost any function—as an amplifier, oscillator, squarewave generator or voltage comparator. They are used in a wide range of simple chemical and electrical instruments. Their main limitation, the inability to amplify high-frequency signals, does not restrict their use in most chemical instruments. Yet, opera-

tional amplifiers are cheap: those manufactured in India cost less than US\$2, and equivalent US and Japanese opamps cost even less.

The growing disparity between the availability of versatile, low-cost electronic components and the rising cost of chemical instrumentation has enticed various groups of university teachers to design and build their own chemical equipment and instrumentation. One group of chemistry and physics teachers from the University of Delhi were encouraged by Prof. C. N. R. Rao, and Prof. D. J. Waddington, (of the IUPAC Committee on Teaching of Chemistry), and Dr. J. V. Kingston (Division of Scientific Research and Higher Education, UNESCO) to initiate a project under the sponsorship of IUPAC and UNESCO. The project was started by Dr. K. V. Sane (the Indian National Representative of the IUPAC Committee on Teaching of Chemistry) and Dr. P. K. Srivastava of the Department of Physics, University of Delhi. They have now been joined by Dr. C. K. Seth (Chemistry Dept), Dr(Mrs) Kamalni Sane (Chemistry Dept), Mr. Ravishankar Bhattacharjee (Physics), and Mr Alok Saxena (Technical Service). Several students volunteered to work on the project during their summer vacations and they became an integral part of the team.

This group decided to focus their efforts on developing conductance and pH meters. They expected that these instruments could be applied in a wide range of qualitative and quantitative analysis experiments, and could illustrate concepts of thermodynamics, kinetics and chemical structure. Fur-



One type of home-made instrument developed by the group in India (shown here) is used for electrochemical analyses, pH measurements and titrations. Although the actual heart of the instrument is one operational amplifier chip, this component accounts for only a small fraction of the instrument's size and cost. Most of the components on the printed circuit board, visible when the back cover is removed from the cabinet (below), are part of the power supply. The physical construction of this instrument is very similar to the companion conductance meter developed by the same group. Components for each instrument cost about US\$40.

Low-cost electrodes for both instruments are made with graphite rods recovered from discarded transistor radio batteries. To measure copper, zinc or other metal ion concentrations, the rods are electroplated with a coating of the metal to be analyzed. Cells for conductance measurements are made with two uncoated rods, rigidly supported in a glass tube by a rubber stopper or epoxy. These perform as well as very expensive conventional cells, made with platinum electrodes. Cells with built-in heating coils (second cell from right, above) are used for conductance measurements at elevated temperatures.



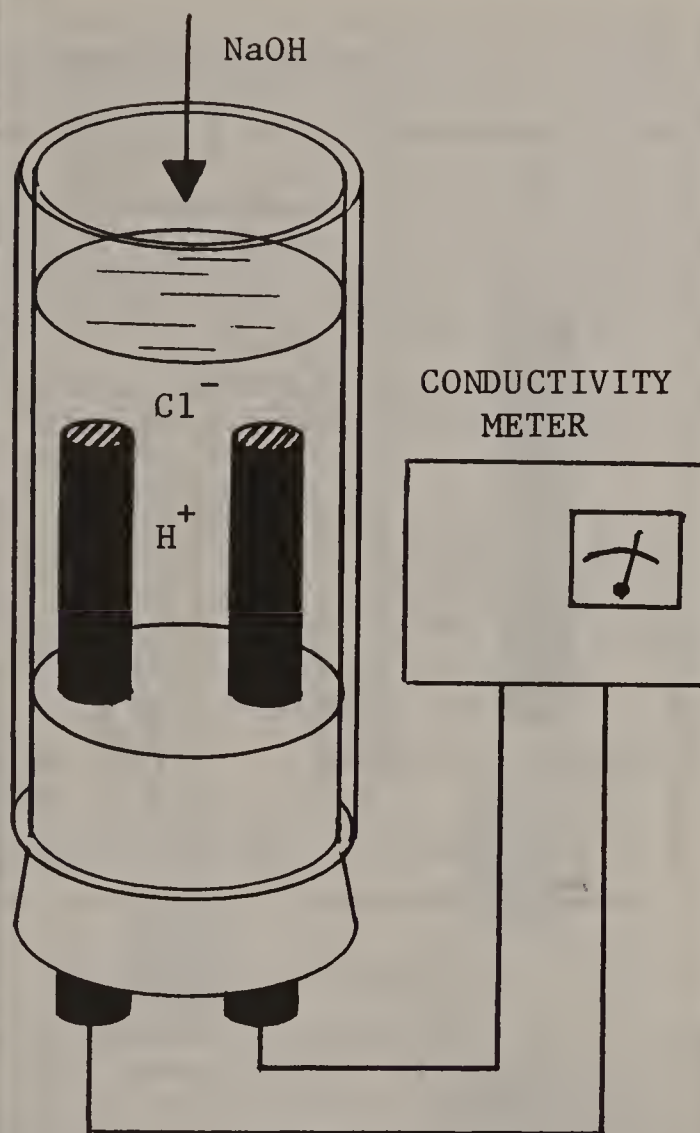
thermore, it seemed that these instruments could be built with very simple circuits utilizing operational amplifiers.

Their expectations were soon confirmed. By the end of the first year of the project, the group found that, for as little as US\$20, they could fabricate instruments that were adequate to perform conductometric and potentiometric titrations. They had already reached a stage at which the measuring apparatus was cheaper than a commercial conductance cell! It was evident that, to achieve their ultimate objectives, they would need to make their own low-cost electrodes, as well as build simple electronic instruments. This was not simply a matter of duplicating the design of manufactured conductance cells and other electrochemical devices, as these are made with platinum electrodes. A different approach was necessary: they needed to find an inexpensive substitute for platinum that provided the same degree of electrochemical inertness.

To make electrodes, members of the group tried using graphite rods extracted from used dry-cell batteries. These were cleaned with sandpaper and dilute chromic acid solution, and then inserted into home-made conductance cells. To their delight, they found that the graphite electrodes performed in all respects as well as platinum. They later discovered that the excellent characteristics of graphite as an electrode for electrochemical measurements had already been reported by several researchers in recent papers. However, the extraordinary versatility of graphite rods as electrodes for undergraduate chemistry experiments had apparently not been recognized.

Conductance cells made with graphite rods were not only useful for physical chemical measurements, but could often be used to monitor the progress of a reaction and to indicate the endpoint of a titration. The equivalence point of many reactions can be identified by a distinct break in the rate of change of electrical conductivity. When HCl is titrated with NaOH, for example, the highly-mobile H^+ ions are formed into neutral water molecules, and replaced by less-mobile sodium ions. Electrical conductivity of the HCl solution declines as NaOH is added. After all HCl has been neutralized, however, H^+ ions are no longer removed from solution when more titrant is added, and the conductivity of the solution therefore begins to increase. When a bifunctional acid (like oxalic acid) is titrated, both endpoints of the neutralization reaction are apparent from a graph plot of conductivity versus titrant volume.

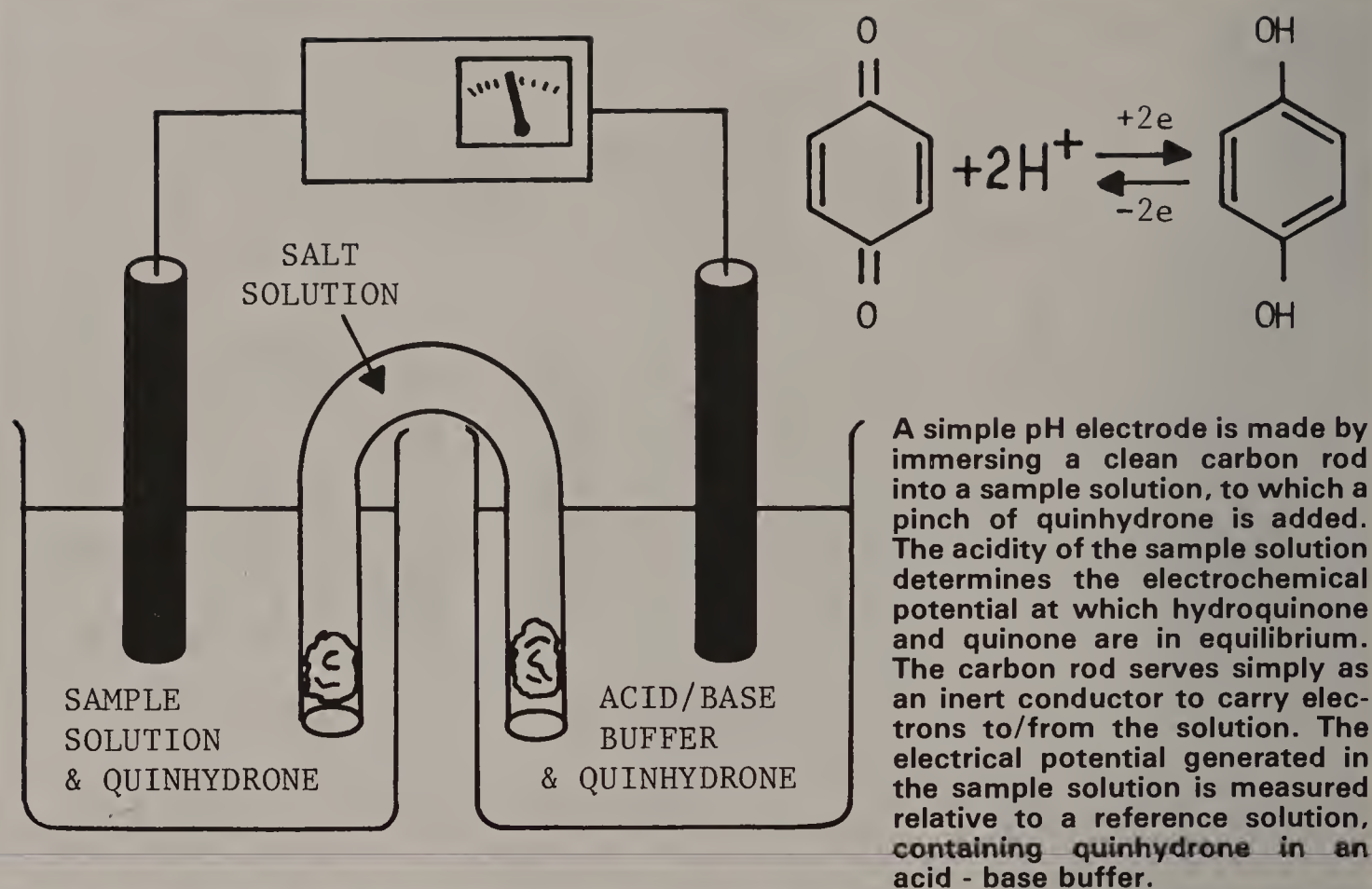
Carbon rods, unlike electrodes made of platinum, will not form a leak-tight seal in glass. The Delhi group found that their graphite electrodes could be sealed in teflon, but such cells would be too expensive and difficult to fabricate. They were able to construct cells adequate for most purposes by simply inserting the rods through holes in a rubber cork, and placing the cork into a glass tube. For experiments using solvents or reagents that would attack rubber, epoxy resin is used to seal the electrodes into a glass tube. The various types of inexpensive cells that have now been developed allow electrochemical measurements to be made under all experimental conditions likely to be encountered. Special-purpose cells have also been constructed (with built-in heating



Since many chemical reactions are accompanied by a change in solution conductivity, a conductivity cell can be used to monitor the rate or extent of a reaction. One may, for example, detect the endpoint of an acid-base reaction, as depicted here. Hydrogen ions that are initially present impart a high conductivity to the solution. Addition of NaOH causes hydrogen ions to be removed from solution, and replaced by less-conductive sodium ions. The electrical conductivity of the solution falls until all HCl is neutralized. Then, addition of more NaOH increases the conductivity of the solution.

coils) to measure electrical conductivities of solutions at elevated temperatures.

Graphite rods also proved suitable for monitoring the electrochemical potential of solutions, which is determined by the relative concentrations of oxidized and reduced ions (for example, Fe^{+3} and Fe^{+2}). This is the basis of a simple electrode used to measure solution pH (conventional pH electrodes employ a H^+ -selective glass membrane, which is very thin, fragile and difficult to fabricate). A clean carbon rod is dipped into the sample solution, to which is added a pinch of quinhydrone (a crystalline salt containing hydroquinone and the oxidized form of the compound, quinone). The hydroquinone/quinone mixture can be reversibly oxidized or reduced, and in so doing, it liberates or binds hydrogen ions. A change in hydrogen ion concentration of the solution shifts the oxidation/reduction equilibrium. Consequently, the electrical potential of the solution varies logarithmically with the concentration of hydrogen



ions (and thus, varies linearly with solution pH). The quinhydrone pH electrode provides reliable measurements in acid, neutral and slightly basic solution (up to about pH 9.5), but becomes erratic in very alkaline solution.

In addition to the pH-sensitive half-cell (composed of a graphite electrode immersed in sample solution with quinhydrone), a reference half-cell (providing a constant potential) is needed. Traditionally, a calomel electrode is used for a reference half-cell. A simple substitute, that has been found to provide adequate results, is the so-called "quinhydrone reference electrode". This is prepared by immersing a carbon rod in a quinhydrone solution whose pH is held constant by an acidic buffer. Since the concentrations of hydroquinone, quinone and hydrogen ions remain constant, the half-cell generates a fixed potential.

A salt bridge couples the pH-sensitive half-cell to the reference half-cell. The salt bridge provides an electrical path between the sample and reference solutions, but prevents the two solutions from mixing. Generally, it consists of an inverted U-shaped tube filled with an agar jelly, or with electrolyte solution held between two plugs of filter paper.

Graphite rods are also an ideal base onto which metals can be electroplated. The metal coating, unlike the inert surface of graphite (which merely maintains electrical contact with the solution), serves as an electrochemical reactant. The electrocoated rod and solution form an electrochemical half-cell, whose potential varies with the metal ion concentration. Thus, electrodes can be specially tailored to measure concentrations of copper, zinc or other metals. These could be used, for example, to detect the sudden release of complexed metal ions at the endpoint of a compleximetric titration.

To fabricate electrodes that respond to only one

particular ion with high selectivity, ion-conducting salts or ion-selective liquid membranes can be utilized. In one experiment adapted by the Delhi group, a Cu^{+2} -selective ion-conducting salt is prepared from a mixture of Ag_2S and CuS , and pressed into a hard, durable, insoluble disc (with a KBr pellet press). The disc is mounted over the end of a glass or plastic tube, into which is placed a $Ag/AgCl$ electrode and reference solution. Using the same technique, electrodes can also be prepared to selectively measure concentrations of lead, cadmium, chloride or bromide ions. It is also possible to prepare all-solid-state ion-selective electrodes by attaching the salt disc directly to the end of a graphite rod, using electrically-conducting epoxy to provide electrical contact and a liquid-tight seal.

The range of ions which may be analyzed with ion-selective electrodes might be greatly expanded by using ion-selective "liquid membranes" (see feature article in this issue). These membranes can be prepared very easily, using chemicals that are readily available and low in cost. Membrane components are dissolved in a solvent, and the solution applied to the end of a graphite rod. Evaporation of the solvent deposits a rubbery ion-selective membrane. Although electrodes made in this way are reported to provide selectivity, sensitivity and response time that are inferior to commercial ion-selective electrodes, their performance is probably more than adequate to illustrate the principles of operation to undergraduate students.

These crude electrodes and simple instruments perform remarkably well, perhaps because most chemistry experiments do not require an *absolute* measurement of potential or conductivity. Rather, the student utilizes the instrument to indicate when there is a sudden *change* in ion concentration or oxidation potential such as occurs at the endpoint of a titration.

Initial circuit designs used in the measuring instruments provided sufficient sensitivity and stability for titrations, but could not provide reliable absolute measurements of conductance, pH or cell voltages. Further refinements of the circuits allowed this capacity to be achieved. Although these refinements increased the cost of each conductance meter and pH/millivoltmeter to about US\$35, the new models provided results that were indistinguishable from those obtained with commercial equipment made in India or abroad costing 10 - 30 times as much. The home-made instruments were still more cumbersome to use than the commercial models, although the Delhi group feels that this is not necessarily a disadvantage when the instruments are used by students. The instruments are intended solely to provide experience in the operation of chemical instrumentation, and for this, simplified calibration procedures are not essential—or perhaps, not even desirable.

After developing the instruments to this point, the development group surveyed the chemical literature for experiments for which their instruments would be utilized. Eighty experiments were found, demonstrating principles of biochemistry, soil chemistry, thermodynamics, chemical kinetics as well as analytical chemistry. Many were simple, low-cost experiments, but others were high-level research studies. Each experiment was tested by the Delhi group, and modified and extended as necessary.

Many of these experiments were tested by other chemistry instructors at a week-long workshop held in April 1981 at the Indian Institute of Technology (in Madras), attended by forty participants from India and Southeast Asia. The participants tested eight prototype instruments and built various types of electrode assemblies. Most workshop participants felt that the equipment should be produced in larger numbers so that it could be tested by students under actual laboratory conditions.

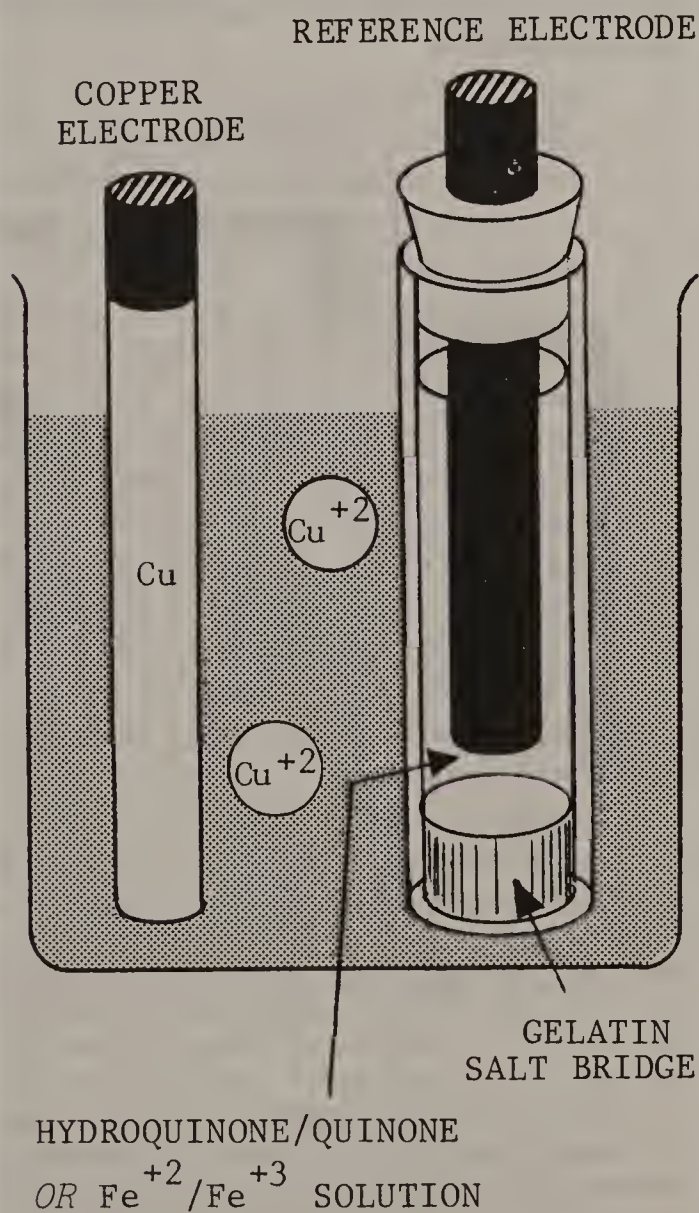
Following this recommendation, the Committee on Science and Technology for Developing Countries (COSTED) provided a grant for construction of 25 pH/millivoltmeters and 25 conductance instruments. For these, the same circuitry was retained, but the physical layout and construction of the instrument were modified to enhance its appearance, durability and ease of maintenance. The higher cost incurred by using a better quality cabinet was largely offset by lower prices of the components purchased in quantity. Final versions of the two instruments cost about \$40 each.

The Delhi group hopes that several centres will be established throughout India for construction of low-cost instrumentation. As well as building instruments, these centres would provide facilities and expertise for their maintenance and repair.

It is important to view a project like this in a proper perspective. Development of a few simple, low-cost instruments is of little significance unless this approach can be uniformly applied to all areas of laboratory instruction in science. Furthermore, it should be realized that there is little need for original discoveries in the design of simple equipment. The literature provides an abundant supply of ideas for instrumentation and experiments. The challenge lies in adapting these ideas to local conditions.

In this respect, it is essential that local groups be innovative, rather than simply “borrow” circuits or experiments directly from the literature. Only in this way can each group cultivate the expertise necessary to modify, maintain, and repair equipment. This would eliminate long delays in obtaining spare parts that are commonly encountered in developing countries, and ensure that trained individuals are located nearby when repair is necessary. The lack of local know-how to maintain and repair equipment is presently a pervasive problem in the Third World. Although chemical instrumentation is in critically short supply, that equipment which is available may be inoperable much of the time.

To develop new instruments, a “package” approach is essential. A particular piece of equipment (for example, a conductance meter) its accessories (e.g. conductance cell), and a collection

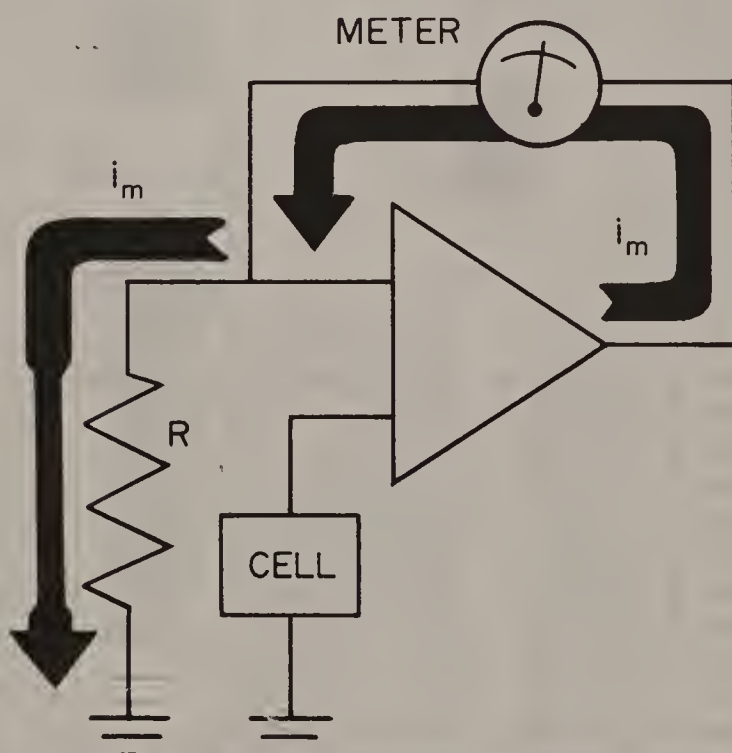
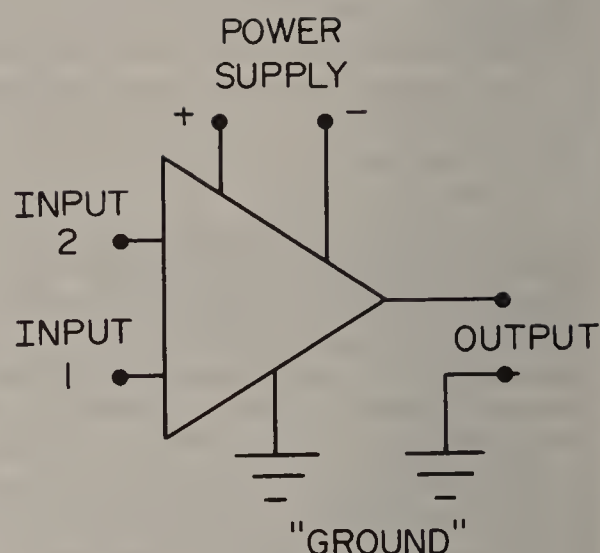


Carbon rods can be tailored to make electrodes for a wide range of electrochemical cells. For example, by electroplating a thin layer of copper onto a graphite rod, an experimenter can easily produce an electrode whose half-cell potential varies with the concentration of copper ions in solution. A reference electrode, which generates a constant half-cell potential, is made by inserting a carbon rod into a solution with fixed concentrations of oxidized and reduced ions. A salt bridge prevents direct interchange of ions between the reference and sample solutions.

How operational amplifiers are used for electrochemical measurements

An "opamp" amplifies the *difference* in potential between the two input terminals. The amplified voltage appears between the amplifier output terminal and "ground" (whose potential is considered to be zero). The factor by which the input voltage is amplified is termed the "open-loop" gain. Ideally, the gain should be infinite, and in actual opamps, gains of 100 million are typical.

Opamps are hardly ever operated as open-loop amplifiers. For most electrochemical measurements, this gain is too high: a one microvolt signal would drive the output voltage to its maximum possible value (determined by the power supply voltage). A more useful approach is to operate the opamp as a *current* amplifier. In this way, we can exploit the relatively high current which the amplifier can deliver from its output terminal, while it draws hardly any input current from the electrochemical cell.



The basic features of a pH meter/millivoltmeter circuit are shown here. The electrochemical cell, whose voltage is to be measured, is connected between one input terminal of the operational amplifier and "ground". The resulting voltage difference across the two input terminals causes a large current (i_m) to flow from the amplifier output, through the meter, and to the second amplifier input terminal. This current increases until the second input terminal reaches the same potential as that generated by the electrochemical cell. A steady-state condition is achieved, in which the output current flows to the second input terminal at the same rate as it leaks away through resistance R . Output current i_m is proportional to the cell voltage, but is much greater than the feeble currents which the cell itself can deliver.

of tried experiments should be developed simultaneously. Construction of any instrument is not an end in itself, but a means to teach good science.

Finally, a mechanism needs to be evolved for non-commercial production of successful prototype instruments, for their distribution (at a price that just covers the cost of production) to institutions all over the country, and for training teachers in the use of new equipment.

The Delhi Group is actively engaged with each of these aspects. They are presently preparing a manual, describing fabrication of the circuits and electrodes, testing and maintenance procedures, and twelve simple experiments that can be performed with the instruments. A first regional workshop was held in Madras to familiarise local college teachers with the instruments, and a second regional workshop is planned for South America in 1982.

This year, the group hopes to begin development

of other low-cost equipment. They initially plan to design a low-cost colorimeter, and possibly a spectrophotometer (able to measure light absorbance over a continuous range of wavelength). They also feel that it is feasible to develop a low-cost Nuclear Quadrupole Resonance (NQR) Spectrometer for advanced chemistry courses. In the past, NQR has been largely overlooked because it does not provide as much structural information about the sample compound as does Nuclear Magnetic Resonance. However, NQR relies on the intrinsic magnetic moment of the nuclei in the sample compound, and therefore does not require a massive electromagnet (by far the largest, most expensive and energy-consuming component of an NMR spectrometer). Basically, all one would need is a radiofrequency generator, detector and electronic amplifier and signal processor. Several designs are available in the literature which can form a starting point for this project.

New ion-selective electrodes allow simple chemical analysis, fast results

For many years, ion-selective electrodes were restricted to pH measurements and a few other specialized applications. The first to be fabricated was the glass pH electrode, based on the discovery that an electrical potential was produced by a glass membrane separating two solutions with different hydrogen ion concentrations. The potential across the membrane varied only with the concentrations of hydrogen ions, and was largely unaffected by the presence of other ions. The response of the glass membrane to hydrogen ions resulted from the strongly basic charged silicate groups on the membrane surface. It was soon realized that this effect could be exploited as an extremely simple and selective method for measuring solution pH. In fact, the glass electrode and accompanying pH meter are now standard equipment for acid-base measurements in virtually all laboratories. Its selectivity for hydrogen ions remains unsurpassed by any other analysis method.

Since the invention of the pH electrode, researchers were able to modify the glass membrane by replacing some silicate groups with aluminosilicates, imparting selectivity towards alkali and silver ions. A few other ion-selective electrodes were made with ion-conducting salts (in lanthanum fluoride, for example, fluoride ions can diffuse through the crystal). However, further development and application of ion-selective electrodes lay dormant for many years. Within the last decade, several fundamental technological advances created a fertile environment for rapid development. Only then could the potential applications of ion-selective electrodes be recognized, and a broad range of new electrodes developed that could analyze metal and non-metal ions—and even complex organic molecules—with high selectivity.

These new ion-selective electrodes provide operating features that cannot be matched by conventional chemical analysis methods. They respond rapidly to changes in concentration of the selected ion, providing a continuous and nearly instantaneous read-out of analysis results. Biological fluids and complex solutions can be analyzed directly, without purification or preliminary treatment of the sample. Only tiny samples are required, and miniature electrodes allow concentrations to be measured within a single animal cell. Ion-selective electrodes respond only to ion concentrations in the sample *solution*, and are not influenced by ions bound to proteins or adsorbed on colloidal particles. When compared with other analysis methods, measurements with ion-selective electrodes are often easier, faster and cheaper to perform.

The great strides made in the development of new ion-selective electrodes, and their likely impact on analytical chemistry, were described at the 1981 IUPAC Congress by Prof. Dr. Wilhelm Simon (of the Swiss Federal Institute of Technology). His lecture* focussed on recent experiments with ion-selective electrodes in biological and medical applications, which demonstrated important advantages over the generally-accepted technique of flame photometry and of atomic absorption spectroscopy. The development of ion-selective electrodes has advanced to such a degree, Prof. Simon concluded, that they will likely displace other methods for monitoring metal ions in biological fluids. Flame photometers, he predicted, will disappear from clinical laboratories within a few years.

* Prof. Simon's lecture, entitled "Ion-selective electrodes in biology and medicine", will be among those included in the proceedings volume of the IUPAC Congress, to be published shortly by Pergamon Press.

The versatility of ion-selective electrodes has been greatly extended through several major technical advances. The first, in which Prof. Simon has played an important role, is the development of ion-selective "liquid membranes". These synthetic membranes have the physical consistency of a rubbery film, but in chemical properties, they resemble a film of hydrophobic liquid. Small, fat-soluble molecules diffuse freely through the membrane. Hydrophilic ions and polar molecules cannot diffuse into the membrane, except for those which become bound to complexing agents dissolved in the membrane.

One interesting example is a new membrane which is selective for hydrogen ions. Electrodes made with this membrane will likely replace the glass electrode for pH measurements in biological fluids. The new liquid-membrane hydrogen-selective electrode can be made extremely small (with a tip diameter of about one micron, allowing pH measurements to be made *within a single cell*). It is far more resistant to mechanical breakage than the glass electrode, and is compatible with biological fluids (it does not become coated with protein, as does the glass electrode membrane).

As in all liquid-membrane electrodes, the H^+ -selective membrane contains primarily a mixture

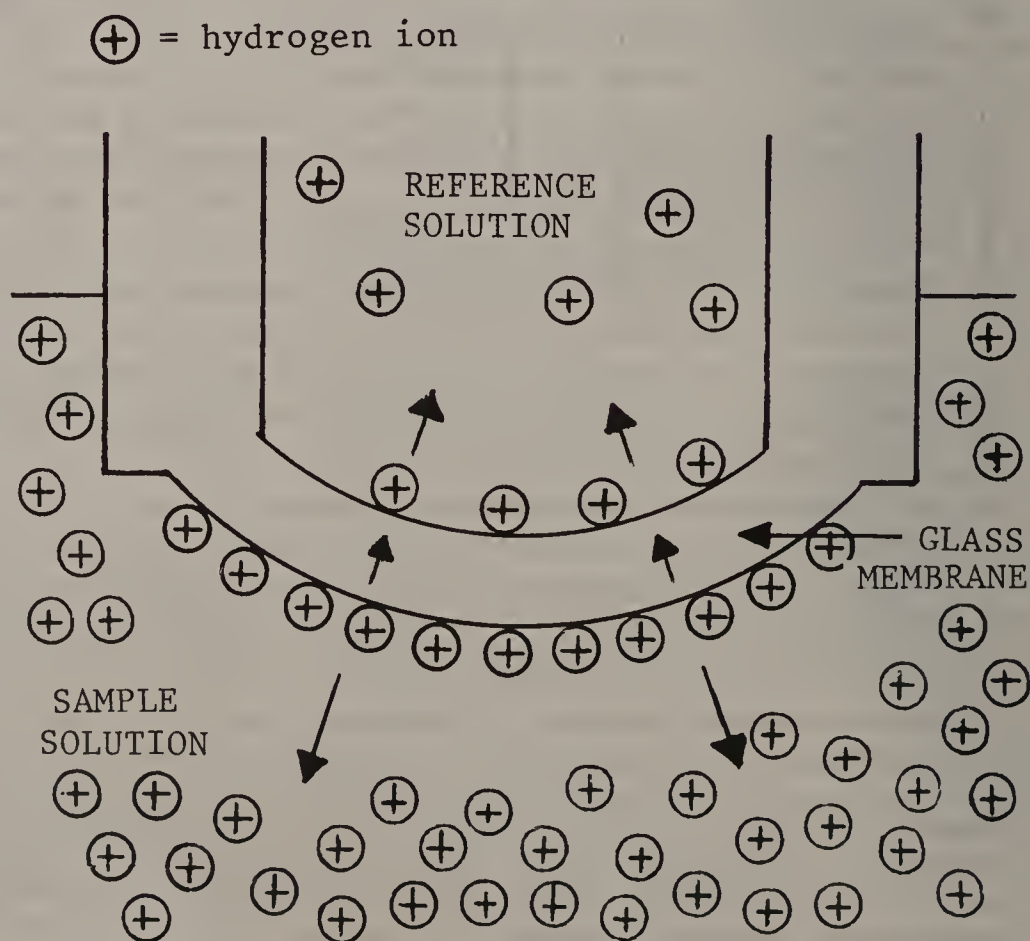
of polymer molecules (generally, polyvinyl chloride) and plasticizers. Since this mixture is a non-polar organic medium, ions are normally unable to enter the membrane. This barrier is broken down *for hydrogen ions* when the simple organic compound, tri-n-dodecylamine, is incorporated into the membrane. This tertiary amine is a specific complexing agent for hydrogen ions. It combines with hydrogen ions to form a quarternary ammonium ion which, although electrically charged, is still fat-soluble and can diffuse through the hydrophobic membrane. When a tri-n-dodecylamine "ionophore" is present, the membrane is permeable to hydrogen ions, but it blocks the passage of other ions. In particular, permeability of potassium or sodium ions is *10 billion* times lower than for hydrogen ions. The hydrogen-selective membrane can thus be used for pH measurements in biological fluids in which concentrations of sodium, potassium or calcium greatly exceed the hydrogen ion concentration.

Liquid membrane electrodes are relatively easy to prepare. The complexing agent is dissolved in a mixture containing solvent, polyvinyl chloride, plasticizers and a small amount of additives. The mixture sets to a rubbery film when the solvent evaporates. The main limitation is the availability of

Although the glass (pH) electrode was the first ion-selective electrode to be introduced, its operation is still not completely understood. A simplified explanation is presented here. When a glass electrode is immersed into a solution, hydrogen ions diffuse to the membrane. There, they become bound to strongly basic silicate groups on the glass surface. Accumulation of the positively-charged hydrogen ions on the surface gives rise to an electric field, which repels H^+ in the solution (and on the opposite side of the membrane). An equilibrium is soon attained, where further diffusion of hydrogen ions to the surface is prevented by electrostatic repulsion.

Let us initially assume, for the sake of simplicity, that the reference solution inside the glass membrane has the same H^+ concentration as the sample solution. Then, hydrogen ions would be bound with equal density to the inside and outside surfaces of the membrane, so there would be no electric field *within* the glass membrane separating the sample and reference solutions. Both solutions would have the same electrical potential.

Let's consider what happens when the electrode is placed into a sample solution which is more acidic. Then, additional hydrogen ions become bound to the membrane's outer surface. A new equilibrium is restored, with increased electrostatic repulsion of hydrogen ions in solution—and those on the opposite side of the membrane. An electric field appears *within* the glass membrane, giving rise to an electrical potential difference between the sample and reference solutions. However, hydrogen ions do not diffuse *through* the membrane.



suitable ionophore compounds. These must be fat-soluble, selectively bind the desired ion, and have low solubility in water. Various types of complexing agents are used. The ability of the antibiotic valinomycin to bind potassium, for example, is exploited in potassium-selective electrodes. Membrane electrodes containing antibiotic ionophores were considered "exotic systems" as late as 1969, which is remarkable, since the valinomycin-based membrane electrode has become the second most widely used ion-selective electrode (only the pH-glass electrode has found wider use).

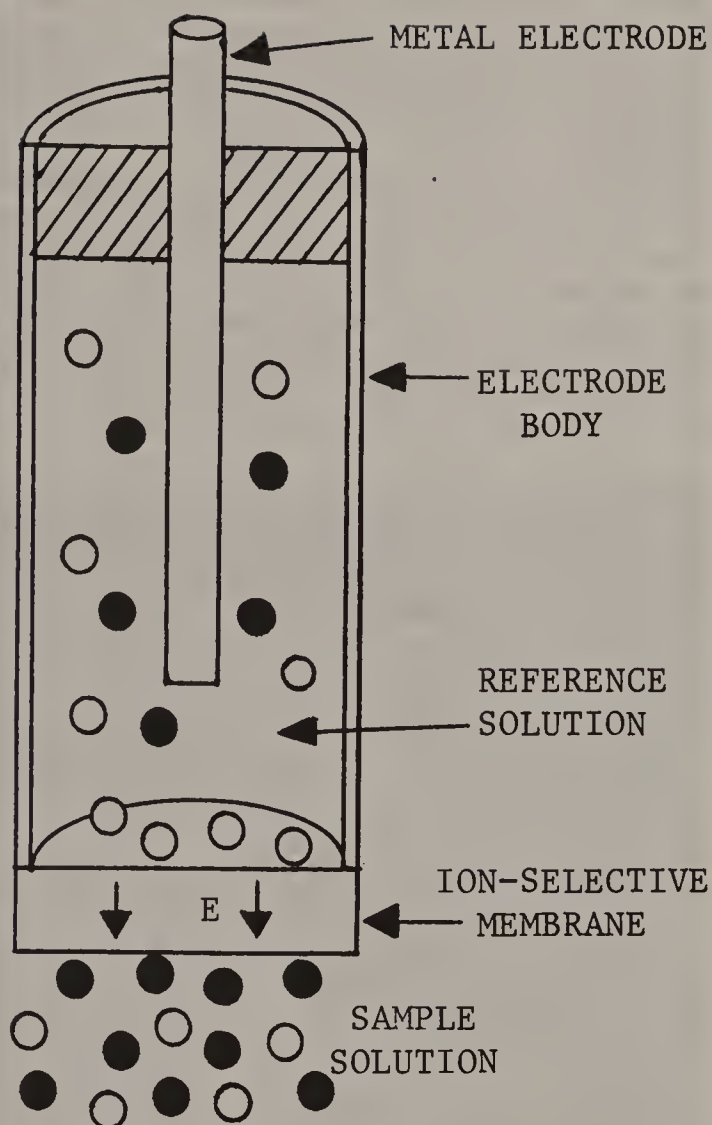
It is important to realize that the transfer of the selected ion through the membrane is not, in itself, of particular significance. Indeed, the quantity of ions that is actually transferred is miniscule. What is important, and what is measured, is the electrical potential which develops across the membrane. This potential arises from the difference in ion concentrations in the two solutions on opposite sides of the membrane: the sample solution to be analyzed, and a reference solution (whose concentration remains constant).

A metal electrode conducts electrical current from the reference solution to the external circuit. The solution/electrode junction comprises an electrochemical half-cell, which generates its own electrical potential. One could, for example, immerse silver metal in a reference solution of silver nitrate. Various reference half-cells are commonly used, but the choice of half-cell is not of fundamental importance. What matters is that the concentration of electroactive ions in the reference solution remains unchanged and, as a result, the electrical potential generated by the half-cell remains constant. Ideally, only the potential across the liquid membrane responds to concentration changes in the sample solution—and that potential depends upon the concentration of the selected ion.

In the case of a potassium-selective membrane, for example, potassium ions become distributed between the aqueous solutions and the membrane phase. Eventually, an equilibrium is reached where the *electrical* potential across the membrane exactly counterbalances the difference of *chemical* potential between the sample and reference solutions (arising from the different concentrations of potassium ions). An electrical potential of about 60 millivolts is produced for each ten fold difference in concentration. When equilibrium is attained, there is no further net diffusion of ions through the membrane.

Of course, for the ion-selective electrode (and its companion reference electrode) to provide electrical current to the input of a measuring instrument, a very small net ion current must pass through the ion-selective membrane. In order that the equilibrium at the membrane not be disturbed, it is essential that the voltage-measuring instrument draws very little electrical current from the electrochemical cell. Even a current drain of one microampere would significantly alter the potential at the ion-selective membrane.

Fortunately, the introduction of liquid-membrane ion-selective electrodes occurred at about the same time as the first field-effect transistors (FET's) were introduced. These electronic devices are ideally suited



Operation of an ion-selective electrode depends upon the electrical potential generated across an ion-permeable membrane. In a potassium-selective electrode, for example, an electric field (E) arises because only positively-charged potassium ions (depicted here in white) permeate through the membrane, while negatively-charged counter-ions (depicted in black) cannot. The electric field increases until it opposes and exactly balances the spontaneous diffusion of potassium ions, resulting from the difference in potassium ion concentration between the sample and interior reference solution.

for measuring voltages produced by ion-selective electrodes. They draw far less current, are much cheaper and are simpler to use than any electronic amplifiers that had previously been available. The amount of current drawn into their input terminal is, for all practical purposes, negligible. However, for this very reason, FET's are subject to electrical noise. Cables from ion-selective electrodes must be well shielded to prevent interference from static charges and stray electric fields.

One recent approach, which largely eliminates noise amplification, is to deposit the ion-selective membrane directly on the input terminal of a field-effect transistor. This entirely eliminates the need for a reference half-cell in the ion-selective electrode and for a cable to connect the electrode to the amplifier input. The amplified output of the FET is far less subject to electrical interference and is transmitted by cable to the measuring instrument. A growing family

of ion-selective field-transistors (ISFET's) is becoming available, although the development of these devices is restricted to large electronics manufacturers.

An ISFET is not simply an ion-selective electrode and an FET which have been combined into one component; its operation is fundamentally different. An ion-selective electrode relies on *electrochemical* processes (the concentration difference at the membrane, oxidation/reduction at the reference electrode) to generate a voltage. By contrast, an FET is an *electrostatic* device and responds directly to the electric field generated in the membrane by ion diffusion. Some researchers have attempted to amalgamate the properties of both devices by depositing an ion-selective membrane directly onto a metal electrode. These hybrid devices work (although

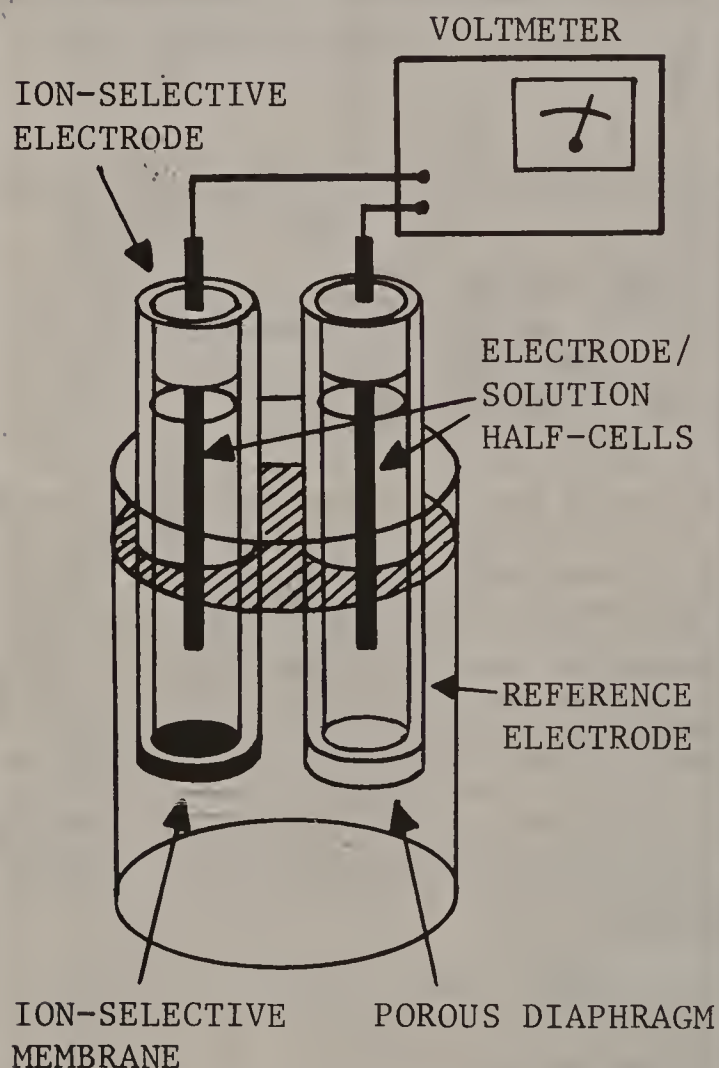
exactly *how* they work is not understood), but do not provide a sufficiently stable voltage.

Ion-selective electrodes have now been prepared for more than 30 metal ions, halide ions and charged radicals. Some of these ions (sodium, potassium, magnesium and calcium) are of particular clinical importance. Analysis of these ions with ion-selective electrodes is not affected by the presence of protein and blood cells. No pre-treatment of a blood sample is required, and analysis results are provided nearly instantaneously and continuously. By comparison, conventional analysis techniques require that cell-free serum be obtained for each blood sample. These methods determine the total amount of metal ions in blood serum, including ions that are bound to proteins. They do not—unlike analysis with ion-selective electrodes—measure the concentration of ions dissolved in the solution component of blood serum. It is the concentration of ions in solution that appears to be of clinical significance.

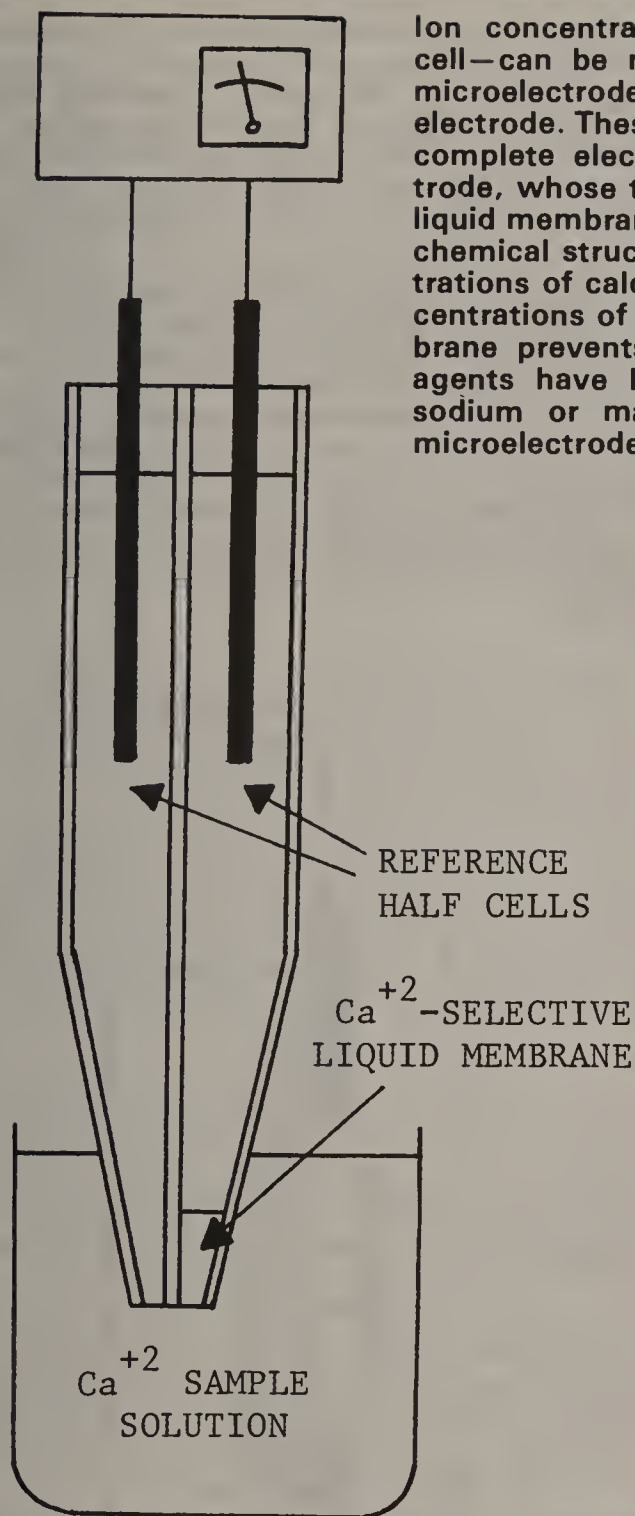
Analysis results obtained by ion-selective electrodes and by atomic absorption spectroscopy may differ considerably. These differences reflect the different properties that are being measured. For example, about 45% of the "total calcium" in blood serum is actually dissolved in solutions and only this fraction is detected by an ion-selective electrode. Atomic absorption measures this component *and* remaining calcium, which is bound to proteins and other complexing agents normally present in blood. The "total calcium" content of blood serum can also be determined with a novel calcium-selective electrode, if this value is desired, by adding acid to the sample (the acid displaces calcium ions from proteins and complexing agents). The ion-selective membrane provides sufficient discrimination against hydrogen ions so that the acid does not interfere with the analysis of calcium.

The response of an ion-selective electrode does not depend, strictly speaking, on the *concentration* of the ion, but on its *activity* in solution. For selected analytical applications, the activity of an ion is proportional to its concentration. By calibrating the electrode with a solution of known concentration, a direct readout of concentration is provided. However, correction factors must be used when measurements made with ion-selective electrodes are compared with results of other analysis methods. A volume correction factor must be applied when comparing measurements of ion concentrations in blood serum, since protein comprises a significant fraction of the volume of blood serum. The content of ions in a given volume of serum (which is measured by atomic absorption spectroscopy) is therefore somewhat less than the concentration of ions *in solution* (as measured by ion-selective electrodes).

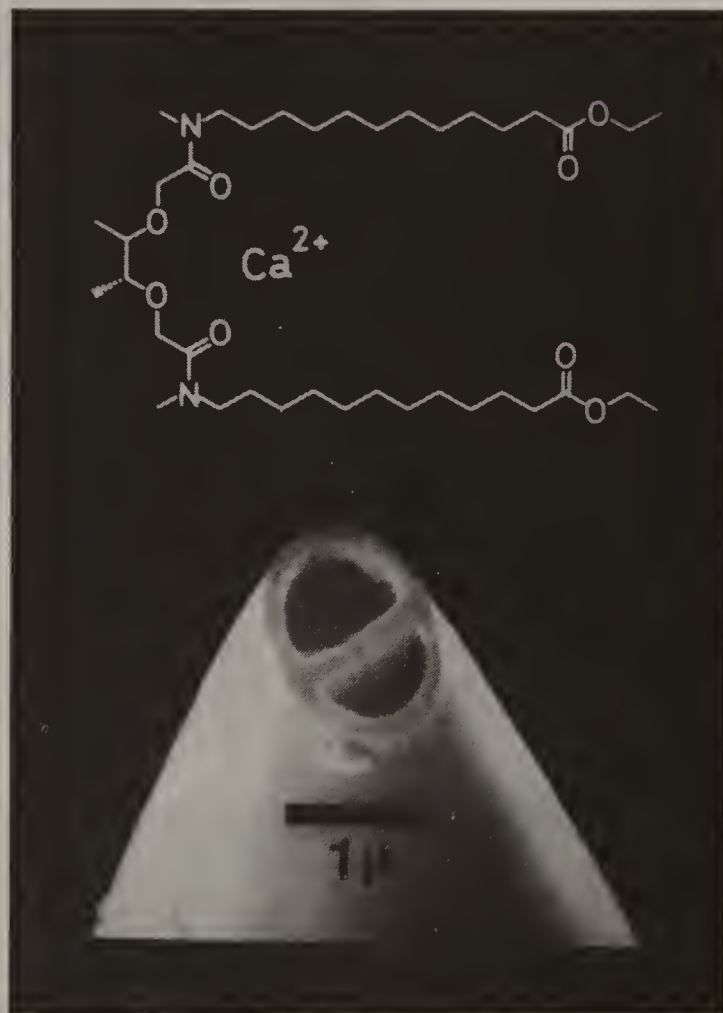
Applications of ion-selective electrodes are not limited to inorganic ions. Electrodes have been developed that provide a specific response to organic ions—and even to uncharged organic molecules. For any particular organic ion, it is often possible to tailor-make an ionophore "host molecule" that can selectively bind this ion. In this way, membranes can be prepared which can discriminate between organic ions with extremely similar structures. Prof. Simon



The potential generated by an ion-selective electrode is measured against a reference electrode, thereby completing an electrochemical cell. The two electrodes may be very similar in construction, but the reference electrode differs in having a non-selective porous diaphragm or salt bridge instead of an ion-selective membrane. Both electrodes contain a metal/solution junction, which gives rise to a half-cell potential. Because very few ions pass through the ion-selective membrane or diaphragm, concentrations of the solutions and their half-cell potentials do not change. Only the potential across the membrane varies with the concentration of the ion being analyzed. Both electrodes can be built into a miniature assembly with a tip diameter of less than one micron.



Ion concentrations within tiny samples—even within a single cell—can be measured by an ion-selective microelectrode. The microelectrode contains an ion-selective electrode and a reference electrode. These, and electrolyte solution in the sample, comprise a complete electrochemical cell. The calcium-selective microelectrode, whose tip is shown in this electron micrograph, employs a liquid membrane with a binding agent selective for calcium (whose chemical structure is shown here). Although intracellular concentrations of calcium are about a thousand times less than the concentrations of magnesium, the high selectivity of the liquid membrane prevents interference by magnesium ions. Other binding agents have been developed to provide selective response to sodium or magnesium ions, and these may be employed in microelectrode membranes. (Photograph courtesy of Prof. W. Simon)

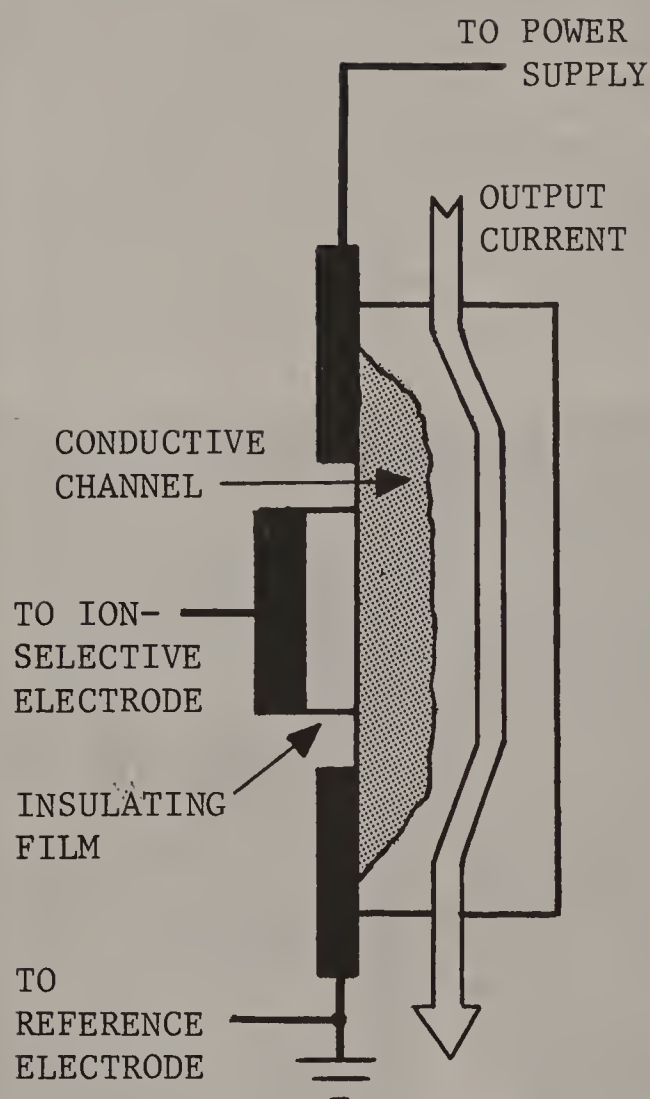


and his coworkers prepared membranes, containing a crown ether ionophore, (designed and prepared by Prof. Lehn and his colleagues) that provided a specific response to phenylethylammonium ions. Their liquid-membrane electrodes responded to this ion with about 100 times more sensitivity than with other organic ions of the same type. Even more impressive, the membrane discriminated between the two enantiomeric isomers of phenylethylammonium ion, providing nearly three times the response to the *d* enantiomer of phenylethylammonium ion than to its mirror image. A second membrane, made with the enantiomeric form of the crown ether host molecule, would provide a preferential response to the *l* enantiomer. By preparing two ion-selective electrodes, whose membranes contained mirror-image forms of the host molecule, the researchers constructed a cell whose voltage provided a direct measure of the relative amounts of *d* and *l* enantiomers in a sample.

This type of analysis is potentially of great importance for the analysis of pharmaceuticals and other optically-active compounds. Many laboratories are

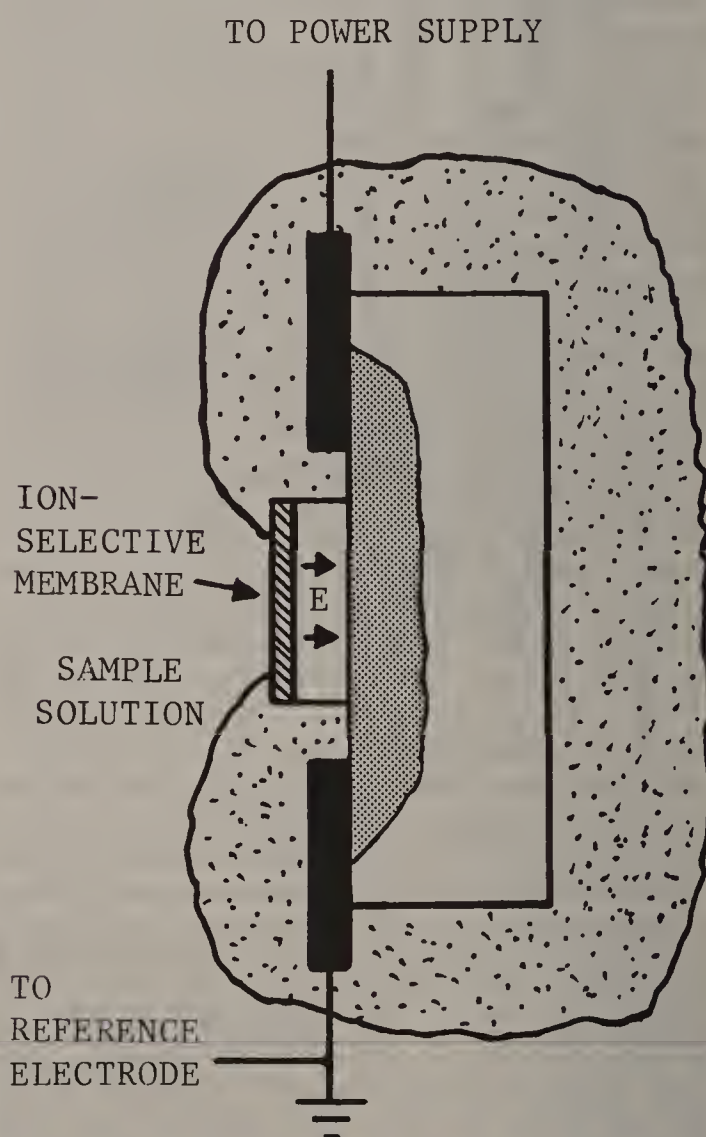
now attempting to synthesize host molecules that can selectively bind one enantiomer of a particular organic ion. Very recently, two researchers (W. Bussmann & W. Simon) reported the construction of an electrochemical cell that could determine the enantiomeric composition of the medically-important compound ephedrine (which is normally ionized as a hydrochloride salt). The cell consists of two ion-selective electrodes; each contains a membrane with one enantiomeric form of the ionophore (an ester of tartaric acid, designed and prepared by Prof. V. Prelog & K. Kovacević).

Ion-selective electrodes will likely be adopted for specific analysis of a wide range of organic compounds. This selectivity is being achieved by utilizing enzymes in the fabrication of ion-selective electrodes. The enzymes are chemically bound or physically trapped within a supporting mesh placed over the ion-selective membrane. When a specific compound is present, the enzyme accelerates a reaction producing ions, to which the ion-selective electrode responds.



An ion-selective electrode and FET amplifier are merged to form an ion-selective field-effect transistor (ISFET), depicted on right. The ion-selective membrane is placed over the highly-sensitive semiconductor channel, replacing the input terminal of an ordinary FET. The electrode/amplifier is immersed directly into the sample solution whose concentration is to be measured. The device is protected from chemical attack by encapsulation in epoxy or silicone rubber, except for the ion-selective membrane, which comes in contact with the solution. Diffusion of ions into the membrane produces an electric field which is transmitted through the thin insulating film, attracting additional charge carriers into the semiconductor channel and increasing the output current.

Since ion-selective electrodes can provide only miniscule currents, their voltage is generally amplified by a field-effect transistor (FET), whose main features are shown on left. An electrically-insulating layer separates the input terminal from an underlying semiconductor layer, so virtually no current flows into the input terminal. The semiconductor film provides a narrow channel for electrical current to flow between the other two terminals. This channel might normally contain mobile electrons and an equal number of positive charges that are localized in the semiconductor crystal. Application of a negative potential to the input terminal repels electrons away from the conducting channel and reduces its conductivity. Conversely, a positive potential on the input terminal draws additional charge carriers into the channel.



One such electrode utilizes a urease enzyme bound to a polyacrylamide-coated nylon mesh. When urea is present in the sample solution, it is decomposed by the enzyme to carbon dioxide and NH_4^+ ions. An NH_4^+ -selective electrode responds to the ammonium ions produced, generating an electrical voltage related directly to the concentration of urea in the sample solution.

A common application of enzyme electrodes is the clinical analysis of glucose, using an ion-selective electrode with a glucose oxidase enzyme. Glucose-sensing electrodes have been reported that are stable, and can measure glucose concentrations as low as

10^{-8} moles/litre. Commercial instruments with enzyme electrodes have been developed for analysis of glucose, galactose, sucrose, maltose and lactose. Researchers have also described the preparation of enzyme electrodes to measure concentrations of specific amino acids (including glutamic acid, asparagine, phenylalanine, lysine and tyrosine), cholesterol, phenol in industrial effluents, ethanol in blood and penicillin. Other applications of enzyme electrodes will almost certainly follow. Enzyme electrodes offer a unique opportunity to develop stable, self-contained probes for specific compounds, which can be fabricated at low cost for widespread use.

Basis for individual IUPAC membership approved at General Assembly in Belgium

At the 31st IUPAC General Assembly held 25 August - 2 September 1981 in Leuven (Belgium), the IUPAC Council approved the basic features of a plan allowing individual chemists to become Affiliate Members of IUPAC. The plan, introduced to counter the argument that IUPAC remains an exclusive "charmed circle" of chemical experts, will allow chemists throughout the world to participate in IUPAC affairs.

Two years ago, following recommendations made at the 1979 IUPAC General Assembly, Dr. Tom West assembled a subcommittee to investigate various options for the union to broaden its support from chemists throughout the world. It faced a difficult task in reconciling opposing viewpoints expressed by various groups. On one hand was a committee, led by former ACS President Glenn Seaborg, which advocated the formation of an International Chemical Society (see letters by Glenn Seaborg and Simao Mathias in *Chemistry International*, 1981, No. 2). Others felt that a global chemical society would weaken national chemical societies and compete against regional federations of chemical societies that had recently been formed in Asia and Latin America (patterned after the European Federation of Chemical Societies). This group insisted that enhanced contact between chemists in different countries should be achieved by strengthening links between national chemical societies and federations. One spokesman, Dr. Eric Parker (Secretary for Public Affairs of the RSC), argued that IUPAC could provide a central focus for additional interactions between chemical societies and federations.

Taking both arguments into account, Dr. West's five-member subcommittee formulated the basic elements of a scheme to maximize participation of chemists throughout the world in IUPAC activities. Its plan allows for an individual chemist to become an Affiliate Member of IUPAC through the science academy or other body serving as that country's member organization of IUPAC. A chemist could become an Affiliate through his national chemical society if there is no IUPAC member organization in his country, or if the member science academy feels that the chemical society is a more appropriate link. This would ensure that the IUPAC Affiliation plan will not compete with existing chemical societies and science academies. Each IUPAC member organization would be free to establish and govern its own affiliation programme. Individual chemists wishing to become IUPAC Affiliates would pay dues through that country's national science academy or chemical society. Furthermore, the Affiliation plan would not interfere with the present relationship between the IUPAC Council and its national member organizations, or with established working procedures of the IUPAC Bureau, Divisions and Commissions.

To encourage individual chemists to become IUPAC Affiliates, it is necessary that IUPAC provides incentives. Dr. West suggested several



Dr. William G. Schneider was elected by the IUPAC Council as the new Vice-President. Most of Dr. Schneider's distinguished career was spent at the National Research Council of Canada, of which he served as President from 1967 to 1980. As Chairman of CHEMRAWN I, the World Conference on Future Sources of Organic Raw Materials (held in Canada in 1978), he had been instrumental in launching the CHEMRAWN program. He is currently a member of the Organizing Committee for CHEMRAWN II. Dr. Schneider will succeed Prof. Nagakura as IUPAC President in two years time.



A new system of dues to be paid by IUPAC's national member organizations was explained by Finance Committee Chairman Prof. Anders Björkman (standing) and endorsed by IUPAC officers (sitting at front table). After a vigorous debate, the Council agreed to form new membership categories according to annual chemical production and usage within each country. They also approved a special status for small and developing countries that would enable them to send an observer to future Council meetings.

possibilities: IUPAC Affiliates might be offered reduced rates for IUPAC publications, reduced registration fees at IUPAC-sponsored conferences, and preferential consideration when places become available for new Commission members.

A second aspect of the Affiliation plan is for IUPAC to invite presidents of all chemical societies to meet in conjunction with the IUPAC General Assembly every two years. In the past decade, a number of meetings of chemical society presidents have been hosted by individual chemical societies (highlights of the 1979 meeting were discussed in *Chemistry International*, 1980, No. 2). Holding these meetings in conjunction with IUPAC General Assemblies, Dr. West points out, would provide additional opportunities for chemical society presidents to discuss common problems and react to them. It would also allow chemical society presidents to become familiar with IUPAC, and with the IUPAC Affiliate scheme. Those from countries which have established an IUPAC Affiliate scheme might be invited to attend Division or Commission meetings as observers, and a selected number (chosen by rotation) might attend Council meetings.

The IUPAC Council voted by a large majority (114 - 6, with 40 abstaining votes) to support these principles. Details of the scheme will be elaborated at an IUPAC Executive Committee meeting in May 1982 by a study group consisting of Dr. West, Prof. V. A. Kabanov (representing Eastern Europe), Prof.

C. G. Overberger (US member of the Bureau), Dr. W. Fritzsche (General Secretary of Gesellschaft Deutscher Chemiker), IUPAC Vice-President W. G. Schneider and IUPAC Executive Secretary M. Williams. Their specific recommendations will be submitted through the Bureau to the Council at the 1983 General Assembly (to be held 18 - 26 August at the Technical University of Denmark, near Copenhagen) and, if approved, will be implemented.

Division Presidents describe priorities for next 2 years

In presenting their reports to the Council, the Presidents of IUPAC's seven Divisions were asked to select a few highlights of recent developments and plans made at the General Assembly, and describe these to the Council. This departure from traditional procedure was initiated by the Union's President Heini Zollinger. He had set an example by putting aside his written address, which had been distributed in advance to Council members, and emphasized his main ideas with an impromptu slide presentation. Prof. Zollinger noted that IUPAC recommended to conference organizers that lecturers be encouraged to *explain*—and not *read*—their lectures. It is only

One of the lighter moments at the General Assembly was the presentation of a "token award" to Dr. Stanley Brown (centre in photo). Although an empty film cannister was the only trophy available, its presentation acknowledged a substantial achievement: the extraordinarily rapid and flawless publication of *Nickel Toxicology*, containing the 43 papers presented at the 2nd International Conference on Nickel Toxicology, (Swansea, Wales; 3 - 5 September, 1980). The hardcover book was published by Academic Press within 10 weeks of the conference. Dr. Brown and other members of the Subcommittee on Environmental & Occupational Toxicology of Nickel were instrumental in organizing the conference.



The award was presented by Prof. David Tonks (right), Vice-Chairman of the Commission on Toxicology. Looking on at the informal ceremony during the Subcommittee meeting is Prof. F. W. Sunderman Jr. (Coeditor of *Nickel Toxicology* with Stanley Brown, Chairman of the Subcommittee, and President of the Clinical Chemistry Division).

reasonable, he felt, that IUPAC should follow its own recommendation. The change certainly led to a more spontaneous and interesting discussion.

Prof. Norman Sheppard, President of the Physical Chemistry Division, discussed plans of the Subcommittee on Chemical Kinetics, whose members had requested Commission status. The IUPAC Executive Committee had responded to this request by asking the Subcommittee to outline a specific programme of new projects. New subject areas at which they intend

to direct their efforts deal with mass transfer, heat transport and properties of materials—subject areas relating to both chemistry and chemical engineering.

Prof. Norman Greenwood singled out the revision, updating and extension of the "Nomenclature of Inorganic Chemistry" as one of the most urgent tasks to be undertaken by the Division on Inorganic Chemistry. This enormous project will take several years to complete. Because the Commission on Nomenclature of Inorganic Chemistry has insuffi-



At the conclusion of the council meeting, Prof. Saburo Nagakura (right) became President of IUPAC. Among the first to congratulate him was Dr. Richard Den Os, Chairman of the Publications Committee.

cient capacity to simultaneously revise material in the previous (1970) edition and to develop new nomenclature, they will carry out the project in two phases. Correspondingly, the book will be published in two parts. The first part will have essentially the same format as the previous edition, and provide general nomenclature for inorganic chemistry. Ten working parties will consider the various chapters in this section. The second part of the book will contain nomenclature for specialized areas of inorganic chemistry, such as Isopoly and heteropoly anions; Ring and chain nomenclature; Polyhedral nomenclature; and Inorganic and coordination polymers (to be prepared jointly with the Macromolecular Division).

Incoming President Prof. J. Mathieu presented the report of the Organic Chemistry Division. He considered the fate of the Commission on Medicinal Chemistry, which had been strongly criticized for its limited accomplishments during the last few years. Following an extensive evaluation, IUPAC Officers had recommended that the Commission be disbanded. Prof. Mathieu attributed the disappointing performance of this Commission to the nature of its subject area, which he felt was too broad to be adequately dealt with by the Commission's 14 members. This dilution of resources might be overcome, he suggested, if a collaborative effort was undertaken between IUPAC and the International Union of Pharmacology

Bad publicity for IUPAC nomenclature is cited by British National Committee

"The majority of practising chemists in Britain are aware of the existence of IUPAC and its involvement in standardization of symbols, units and nomenclature. However, there has been concern recently over how far this 'awareness' extends to practical familiarity with, and use of, IUPAC publications". So stated two members of the British National Committee for Chemistry (of the Royal Society, IUPAC's member organization in the UK) in a letter published in *Chemistry in Britain*, (September 1981, p. 394). In order to ascertain the extent to which British chemists are aware of IUPAC nomenclature publications, Prof. M. J. Perkins and Dr. C. W. Suckling undertook a small-scale survey. Its scope was restricted to organic chemists, and sought to determine their familiarity with nomenclature of organic compounds. Although the survey involved only 29 university professors of organic chemistry, and 22 senior industrial-research chemists, its results could probably be extended to organic chemists throughout the UK, and might apply to chemists in other chemical specializations and other countries.

Prof. Perkins and Dr. Suckling concentrated their survey questionnaire on the new (1979) edition of the *Nomenclature of Organic Chemistry**, which was reprinted last year as a low-cost softcover volume. Only about one-third (36%) of the organic chemistry professors were aware that the new edition of the nomenclature handbook had been published, and the proportion among the industrial group was only slightly greater (41%). Yet, 23% of respondents in both groups felt that IUPAC nomenclature is essential to their own work, and a further 43% thought that it was useful.

Among the respondents who considered IUPAC nomenclature to be essential, nearly all were satisfied that IUPAC nomenclature was adequate for their needs. Those who categorized IUPAC nomenclature as "useful" were more critical: only two-thirds felt that it was adequate.

One general conclusion seems to be that, whilst most chemists use IUPAC and Chemical Abstracts nomenclature, they only rarely turn to a reference

source. Only 5% of the survey respondents refer frequently to IUPAC nomenclature sources; the majority (64%) refer occasionally to a IUPAC nomenclature source book, but 31% never do. This result might have been expected. It suggests that most practising chemists are interested in nomenclature only as a tool to help them pursue other goals and interests.

Since most survey participants were not aware of recent IUPAC publications in their own field of specialization, organic chemistry, we might expect that most would have little familiarity or interest in nomenclature for related chemical specializations. This, in fact, is what the survey shows. Few participants knew that IUPAC Commissions were involved with medicinal chemistry or photochemistry. Only publications dealing with nomenclature of physical organic chemistry were generally known by one group of survey respondents (the university professors). Prof. Perkins and Dr. Suckling noted in their analysis, "the lack of knowledge seems to reflect badly on IUPAC publicity, since the questionnaire (responses) revealed a cautious optimism regarding work in these areas; indeed, a significant proportion of those respondents who did know of these (nomenclature) enterprises were evidently enthusiastic."

To help readers keep abreast of all IUPAC reports, *Chemistry International* provides a summary of nomenclature and technical reports to be published (in the "Recent Reports" section). This is a relatively new feature. In addition, the "Off the Press" section provides a description of recently-published IUPAC books (including nomenclature handbooks, conference proceedings, chemical and solubility data compilations).

*"Nomenclature of Organic Chemistry" (1979 edition) is a 550 page volume, published in hardcover (US\$82.00) and softcover (US\$13.00) editions. It is available from Pergamon Press Ltd, Headington Hill Hall, Oxford OX3 0BW, UK.

(IUPHAR). He supported the formation of a joint IUPAC - IUPHAR Collaborative Study Group on Pharmacology. Such a collaborative effort is justified, he explained, since medicinal chemistry encompasses organic chemistry, pharmacology and other related subject areas. Later in the meeting, the IUPAC Council concurred that the feasibility of the IUPAC Commission or a IUPAC - IUPHAR Commission should be investigated by a joint IUPAC - IUPHAR working group. Their conclusions will be presented to the Council in 1983.

Major accomplishments and future activities of the Macromolecular Division were outlined by its incoming President, Prof. Clement Bamford. He reported that the Commission on Macromolecular Nomenclature had nearly completed work on two reports dealing with nomenclature for inorganic polymers and with polymer classification. During the coming two years, Commission members will concentrate their efforts preparing a report on physico-chemical terms. Prof. Bamford also noted good progress by the Division's other Commission, concerned with Polymer Characterization and Properties. This Commission is planning to initiate a new programme on Poly(electrolytes).

Dr. Tom West, in summarizing present programmes of the Analytical Chemistry Division, described three projects being coordinated by the Division Committee. Seven Commissions are involved in the assessment of various analytical techniques for the report *Determination of Trace Elements in Natural Waters*. Plans have also been formalized for revision of the *Compendium of Analytical Chemistry* (previous edition published in 1978). Financial support has been obtained for compilation of a multilingual *Dictionary of Analytical Terms*, and work is now proceeding. The dictionary will translate analytical chemistry terms in seven languages: Chinese, English, French, German, Japanese, Russian and Spanish.

Activities of the Applied Chemistry Division, described by Dr. Helmut Frehse for retiring Division President Heikki Suomalainen, place a growing emphasis on collaborative studies. Various methods to analyze inorganic contaminants in food, for example, are being evaluated by one Working Group of the Commission on Food Chemistry. Studies presently being undertaken by the Working Group on Inorganic Contaminants will likely lead to publication of recommended test methods for determining selenium, tin, mercury and fluoride in food. Collaborative studies are also being undertaken by their counterpart Working Group on Organic Contaminants. A number of laboratories have participated in the evaluation of their new method for determining N-heterocyclic carcinogens with glass-capillary GLC. The Working Group provided spiked and unspiked samples of smoked ham, and tabulated test results of participating laboratories. In another study, now nearly complete, the Working Group distributed various pesticide formulations to survey participants for analysis of volatile nitrosamines. Several laboratories have also been approached to compare analytical methods for monitoring drug residues in meat and animal feeds. Initial plans call for an interlaboratory evaluation of methods for

Dr. Mary Good is the first woman to become President of a IUPAC Division. As the new head of the Inorganic Chemistry Division, she hopes that extensive revision of the book "Nomenclature of Inorganic Chemistry" can be completed during the first two years of her term. Substantial amounts of new information will be included, and material from the 1970 edition updated and rewritten, so that the new edition will be a comprehensive, up-to-date reference source for inorganic chemists.



Dr. Good's election as Division President is not the first time that she has pioneered a new path for women chemists; she was Chairman of the ACS's board of directors in 1978, and now is Research Director and Vice-President at UOP Incorporated.

sulfamethazine in pig liver and muscle tissue.

Collaborative studies also comprise an integral part of the activities of the Clinical Chemistry Division's Commission on Toxicology. It has recently completed a second interlaboratory survey using the "IUPAC Reference Method for Analysis of Nickel in Serum", and found that test results were more consistent than those reported by the same laboratories in a preliminary survey. Collaborative studies are also being undertaken to determine the reproducibility with which different laboratories can analyze cholinesterases, cadmium and aluminium in biological fluids.

The Commission on Teaching of Clinical Chemistry has been active in developing a "Scheme for a Two-year Postgraduate Course in Clinical Chemistry" which, Division President Dr. Ralph Gräsbeck noted, has now been adopted in Southeast Asia, Eastern Europe and elsewhere. The Commission has also been examining the teaching of clinical chemistry in medical schools, and has begun to prepare a document on this subject.

Chemical Education Committee copes with spreading fame, shrinking funds

Having been singled out by Prof. Zollinger as one of the most dynamic IUPAC groups, the Committee on Teaching of Chemistry was clearly pleased with growing awareness and recognition of their activities. However, the broad approval of the Committee's work, and especially the high regard for the *International Newsletter on Chemical Education*, has done little to elicit additional financial support. The Newsletter, which is distributed free to chemical educators in over 100 countries, is still financed solely by a modest UNESCO grant which has not increased in value to keep pace with inflation. Unless the Committee obtain an additional source of funding (perhaps by charging recipients of the Newsletter), they will be forced to restrict the circulation or content of the Newsletter.

If the Committee needed a demonstration that difficult challenges could be tackled by a few dedicated individuals—with virtually no financial support—one was immediately at hand. The Committee's National Representative for India, Dr. K. V. Sane, described how the increasing cost and sophistication of chemical instrumentation has virtually excluded their use from chemical education courses in India. Education budgets in developing countries like India are very restricted, he explained, and stringent controls are imposed on the purchase of imported equipment. Thus, while industrial laboratories need graduates who can confidently operate chemical instrumentation, most students receive no training or experience whatsoever in the operation of chemical instrumentation.

With the sponsorship of the IUPAC Committee on Teaching of Chemistry and UNESCO, Dr. Sane helped form an interdisciplinary group to design and build low-cost instruments using only components made in India. Working with very little money and entirely with their own time, his group managed to develop a general-purpose pH meter/millivoltmeter and a conductance meter that can be used in a wide variety of chemistry experiments (see feature article in this issue).

Noting that "a picture is worth a thousand words" and that the actual article is better than a picture, Dr. Sane pulled the instruments from his briefcase and exhibited them to the committee. The total cost of the components required to build each instrument and fabricate electrodes was only about US\$40. This is remarkable in itself, as equivalent commercial equipment made in India costs ten times as much, and imported instruments cost about \$1000. Yet, the home-made instruments compare favourably in performance. They are ideally suited for teaching students the principles of chemical instrumentation and giving them working experience. Dr. Sane hopes

that other chemical educators will be encouraged to build their own instruments, adapting his design when necessary to utilize components that are readily available and inexpensive.

This approach is not only suitable for developing countries, commented Prof. Aleksandra Kornhauser, (from Yugoslavia) but also is appropriate in the industrialized countries. There too, tight education budgets have significantly curtailed the amount and types of equipment available for students use. She noted that the need to bring chemistry teachers back into the laboratory was one of the important challenges identified at recent chemical education conferences*. Many conference participants felt that the chemistry teacher needed to find, together with his students, real problems to solve in the laboratory.

A major responsibility for chemical educators highlighted at these conferences was laboratory safety. It is now recognized that safety should be considered an important criteria in selecting experiments to be performed by undergraduates, and even graduate students. Common laboratory reagents span a millionfold range of carcinogenic potential, while others pose special hazards of acute poisoning, fire or explosion. On this point, a very interesting idea was presented to the committee by Prof. A. Guerrero (of Argentina). He felt that all laboratory manuals should have explicit instructions regarding the hazards posed by each experiment and the disposal of wastes generated by the experiment.

**6th International Conference on Chemical Education (IUPAC-sponsored), held in Maryland USA on 9 - 14 August, 1981. A proceedings volume and a "Source Book for Chemistry Teachers" (prepared in connection with the conference) are available from Dr. Marjorie Gardner, Department of Chemistry, University of Maryland, College Park, Maryland 20742, USA.*

CHEM ED 81, held at the University of Waterloo (Ontario, Canada) on 4 - 7 August, 1981. A conference report is available from Prof. Reg Friesen, Department of Chemistry, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1.

The national conference of the Chemical Education Division of the Royal Australian Chemical Institute was held in May 1981, dealing with the theme "The 1980's: A Challenge and Responsibility for Chemical Education". A proceedings volume is available for A\$8 (including postage) from Mr. C. L. Fogliani, Dept. of Applied Science & Environmental Studies, Mitchell College of Advanced Education, Bathurst NSW 2795, Australia.

OFF THE PRESS

Recent IUPAC publications

Frontiers of Chemistry (Proceedings of the IUPAC Congress)

The IUPAC Congress brings together leaders of the world chemical community to discuss topics at the forefront of research in pure and applied chemistry. The Proceedings provide a general overview of the most important recent work and its significance for the future. This multidisciplinary volume brings together topics as diverse and important as biotechnology, alternative energy sources, synthesis of antibiotics, and combustion processes in fossil fuel conversion.

Prof. Keith Laidler edited the 380 page hardcover proceedings volume, containing 27 keynotes and plenary lectures presented at the 28th IUPAC Congress, held 16 - 22 August 1981 in Vancouver, Canada. The volume is scheduled for publication in March at a cost of about £45, or US\$90.

Subjects covered in the Congress proceedings volume are:

PLENARY LECTURE

Binding of Carbohydrate Structures with Antibodies and Lectins

THE SOLUTION OF ENERGY PROBLEMS

Electrochemical Solar Cells

Pollutant Formation and Destruction in Flames

THE STUDY OF THE ENVIRONMENT

Stratospheric Chemistry

Wastewater Biotechnology

Corrosion in the Polluted Environment

UPGRADING OF RESOURCES

Uranium Chemistry in the Nuclear Industry

Chemistry and the Soil Environment

Wood Chemistry in Pulping Studies

Biotechnology—Trends in the '80s

COMPUTERS IN CHEMISTRY

Molecular Structures and Reaction Mechanisms

Computational Trends in Theoretical Chemistry

Beyond Mere Automation

Studies of Biomolecular Structure and Function

ANALYTICAL CHEMISTRY

Mass Spectrometric Analysis of Organic Ions

Ion Selective Electrodes in Biology and Medicine

INORGANIC CHEMISTRY

Metal Atoms in Synthesis and Related Aspects

Reductive Elimination

Macropolycyclic Structures

ORGANIC CHEMISTRY

Biomimetic Chemistry

Total Synthesis of Polyether Antibiotics

Resolving Mechanistic Ambiguities

PHYSICAL CHEMISTRY

The Role of Catalysts in Alternative Energy Sources

X-Ray Diffraction for Structure Determination

Radical Reaction Kinetics by Time-Resolved ESR

Vibrationally High Molecules

Studies of Gas - Surface Encounters

Macromolecules

This book presents an overview of modern research on both polymers and biopolymers, as was reported at the 27th International Symposium on Macromolecules (held 6 - 9 July 1981 in Strasbourg, France). It describes new syntheses, mechanistic studies and new techniques for structure determination. For several new polymers whose structure and properties have been determined, interesting applications are discussed.

The 346 page hardcover volume, edited by H. Benoit and P. Rempp, contains 22 lectures presented at the conference. It is expected to be available in March at a low cost of approximately £45, or US\$90.

Oxides of Nitrogen (Solubility data)

This volume presents experimental solubility data for gaseous nitrous oxide and nitric oxide in liquids, as reported in the scientific literature. It covers solubility of nitrous oxide in water, seawater, aqueous electrolytes and non-electrolytes, aqueous colloids, organic compounds, and biological and miscellaneous fluids. Solubility data for nitric oxide in water, salt solutions, organic and inorganic solvents are also provided. The book, the 8th volume in the IUPAC Solubility Data Series, presents tables of smoothed mole fraction solubility values for systems which have been studied over a range of temperatures, and critically evaluates the experimental data.

Edited by C. L. Young, the 384 page hardcover volume cites 600 literature references. Its price is £50, or US\$100.

CONFERENCES

IUPAC meetings are indicated in bold type

Additional information from address in parenthesis

1982

SAFE USE OF SOLVENTS

March 23 - 27. International Symposium on the Safe Use of Solvents. Brighton, UK.

(Secretariat, International Symposium on the Safe Use of Solvents, P.O. Box 121, Oxford, UK.)

CLINICAL CHEMISTRY

April 19 - 22. International Congress on Automation in Clinical Laboratory. Barcelona, Spain.

(Dr. R. Galimany, Sección de Automatización, Laboratorio de Analisis Clínicos, C. S. "Principes de España", Hospitalet de Llobregat, Barcelona, Spain.)

SOLUTE - SOLVENT INTERACTIONS

July 4 - 10. 6th International Symposium on Solute - Solute - Solvent Interactions. Minoo, Osaka Prefecture, Japan.

(Prof. Hitoshi Ohtaki (Department of Electronic Chemistry, Tokyo Institute of Technology at Nagatsuta, Nagatsuta-cho, Midori-ku, Yokohama, 227 Japan.)

COMPUTERS IN CHEMICAL RESEARCH

July 11 - 16. 6th International Conference on Computers in Chemical Research and Education (ICCCRE). Washington, DC, USA.

(Dr. Stephen R. Heller, Chairman, 6th ICCCRE, EPA, MIDSD, PM-218, 401 M Street, SW, Washington, DC 20460, USA.)

PHYSICAL ORGANIC CHEMISTRY

July 11 - 16. 6th IUPAC Conf. on Physical Organic Chemistry. Louvain-la-Neuve, Belgium.

(Prof. A. Bruylants, Université Catholique de Louvain, Laboratoire de Chimie Générale et Organique, Bâtiment Lavoisier, 1 Place Louis Pasteur, 1348 Louvain-la-Neuve, Belgium.)

MACROMOLECULES

July 12 - 16. IUPAC Macromolecular Symposium. Amherst/MA, USA.

(James C. W. Chien, Dept. of Polymer Science & Engineering, University of Massachusetts, Amherst, Massachusetts 01003, USA.)

SELECTIVE POLYMER SORBENTS

July 19 - 22. 23rd Prague Microsymposium "Selective Polymer Sorbents". Prague, Czechoslovakia.

(Dr. F. Svec, c/o Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského n.2, 162 06 Prague 616, Czechoslovakia.)

NON-AQUEOUS SOLUTIONS

July 19 - 23. 8th International Conference on Non-Aqueous Solutions. Nantes, France.

(PHAM VAN HUONG, Laboratoire de Spectroscopie Infrarouge et Raman, Université de Bordeaux 1, 351 Cours de la Libération - 33405 Talence, France.)

PHOTOCHEMISTRY

July 25 - 30. 9th IUPAC Symposium on Photochemistry. Pau, France.

(Prof. J. Joussot-Dubien, Laboratoire de Chimie Physique A, Université de Bordeaux I, F-33405 Talence, France.)

MARINE NATURAL PRODUCTS

July 26 - 30. 4th International Symposium on Marine Natural Products. Tenerife, Canary Islands, Spain.

(Prof. A. G. Gonzalez, Department of Organic Chemistry, University of La Laguna, Tenerife, Spain.)

NATURAL PRODUCTS

August 2 - 7. 13th International Symposium on Chemistry of Natural Products. Pretoria, South Africa.

(Mrs. Jeanne Beck, Symposium Secretariat - S.219, CSIR, P.O. Box 395, Pretoria 0001, Republic of South Africa.)

EFFLUENTS OF COAL-FIRED PLANTS

August 16 - 18. International Conference on Coal-Fired Power Plants and the Aquatic Environment. Copenhagen, Denmark.

(Mr. P. Schjødtz Hanse, Director V K I (Water Quality Institute), 11, Agern Alle, DK-2970 Hørsholm, Denmark.)

ORGANIC SYNTHESIS

August 22 - 27. 4th International Conference on Organic Synthesis. Tokyo, Japan.

(Prof. Teruaki Mukaiyama, Department of Chemistry, Faculty of Science, The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113, Japan.)

CARBOHYDRATES

August 22 - 28. 11th International Carbohydrate Symposium. Vancouver, Canada.

(Dr. G. C. S. Dutton, Department of Chemistry, University of British Columbia, Vancouver, BC V6T 1Y6, Canada.)

COORDINATION CHEMISTRY

August 23 - 27. 22nd International Conference on Coordination Chemistry. Budapest, Hungary.

(Prof. M. T. Beck, Institute of Physical Chemistry, Kossuth Lajos University, Debrecen 10, H-4010, Hungary.)

POLYMER STRUCTURE & PROPERTIES

August 29 - September 2. "Interrelations between Processing, Structure and Properties of Polymeric Materials. Athens, Greece.

(Prof. P. S. Theocaris, Chair of Applied Mechanics, National Technical University of Athens, Athens, Greece.)

PESTICIDE CHEMISTRY

August 29 - September 4. 5th International Congress of Pesticide Chemistry. Kyoto, Japan.

(Rikagaku Kenkyusho (The Institute of Physical and Chemical Research), 2-1 Hirosawa Wako-shi Saitama Pref 351, Japan.)

THEORETICAL CHEMISTRY

August 30 - September 3. International Symposium on Theoretical Organic Chemistry. Durbrovnik, Croatia, Yugoslavia.

(Dr. Ante Graovac, Institute "R. Bosković", P.O. Box 1016, 41001 Zagreb, Yugoslavia.)

MYCOTOXINS AND PHYCOTOXINS

August 31 - September 2. 5th International IUPAC Symposium on Mycotoxins and Phycotoxins. Vienna, Austria.

(Prof. Palle Krogh, Head, Department of Microbiology, Royal Dental College, Juliane Mariesvej 30², DK-2100 Copenhagen 0, Denmark.)

RAMAN SPECTROSCOPY

September 6 - 12. 8th International Conference on Raman Spectroscopy. Bordeaux, France.

(Prof. J. Lascombe, Université de Bordeaux 1, 351, cours de la Libération, 33405 Talence Cedex, France.)

CHEMICAL THERMODYNAMICS

September 7 - 10. 7th International Conference on Chemical Thermodynamics. London, UK.

(Prof. M. L. McGlashan, Department of Chemistry, University of College London, 20 Gordon Street, London WC1H 0AJ, UK.)

CHEMISTRY RELATING TO AGRICULTURE

December 6 - 10. Chemical Research to Meet the World's Expanding Food Needs (CHEMRAWN 11). Manila, Philippines.

(Dr. Charles S. Dennison, Executive Director, Council on Science & Technology for Development, 2010 Massachusetts Avenue NW, Washington, DC 20036, USA.)

IUPAC CONGRESS

June 4 - 12. 29th International Congress of Pure & Applied Chemistry. Cologne, Federal Republic of Germany.

(General Secretariat of the 29th IUPAC Congress, Dr. W. Fritsche, c/o Gesellschaft Deutscher Chemiker, P.O. Box 900440, D-6000 Frankfurt/M 90, Federal Republic of Germany.)

ANALYTICAL CHEMISTRY

July 17 - 23. SAC 83 Conference and Exhibition, organised by the Analytical Division of the Royal Society of Chemistry, University of Edinburgh, Edinburgh, UK.

(Dr. J. M. Ottaway, Department of Pure & Applied Chemistry, University of Strathclyde, Cathedral Street, Glasgow G1 1X1, UK.)

IUPAC GENERAL ASSEMBLY

August 18 - 26. 32nd IUPAC General Assembly. Lyngby/Copenhagen, Denmark.

(IUPAC Secretariat, 2-3 Pound Way, Cowley Centre, Oxford OX4 3YF, UK.)

POLYMERIZATION OF HETEROCYCLES

September. Int'l Symposium on Polymerization of Small Heterocycles and Aldehydes. Poland.

(Prof. Z. Jedlinski, Polish Academy of Sciences, Polymer Institute, P.O. Box 49, Curie-Skodowskiej 34, PL-41 800 Zabrze, Poland.)

MACROMOLECULES

September 5 - 9. 29th International Symposium on Macromolecules. Bucharest, Romania.

(Acad. Cristofor Simionescu, Institutul de Chimie Macromoleculara Petru Poni Aleea Grigore Ghica Voda Nr. 41A, Iasi, Romania.)

THE LAST WORD

(continued from p. 28)

of 80×9.81 —call it 785 newtons. But this force pressed me down onto my size nine boots, 373 square centimetres of which were in direct contact with the ground. So my life was spent compressing mother earth with a pressure of 21 kilopascals.

I now had a slightly better idea of the size of my quarry. What I wanted now was an object somewhat smaller than me. My musings ended as I finished the coffee. Pausing only to measure the diameter of the mug, I carried out "the calculation". And the answer? My mug of coffee had pressed down on my desk with 1.03 kilopascals.

This was the nearest I'd come to the kilopascal; I'd trapped him in a mug of coffee? Here was cause for celebration—so off I went to a Chinese restaurant. Sitting at a secluded table, I ordered a pint of beer, and pondered over pressure in liquids. A long-forgotten schoolday formula popped into my mind: pressure-equals-height $\times$ density. To convert to SI units I'd have to multiply by 9.81, but this was worth the trouble because it produced a formula that would reveal the kilopascals lurking at the bottom of any given height of any given liquid. I tested my new weapon by using it to verify that 7.5006 millimetres of mercury did

indeed conceal one kilopascal.

By this time my own beer had come so, with the aid of a chopstick, I measured its depth: exactly 106 millimetres. Using my new weapon, I was able to show that the kilopascal lurked at the bottom of a pint of water, milk, beer, blood, sweat, or urine.

So I'd trapped the kilopascal in a pint of beer! But my victory was incomplete because I still did not know what he felt like. Of course, I still had my mug of coffee to fall back on, but that was a cumbersome form of the kilopascal. What I wanted was something more convenient; preferably something I could carry in my pocket. . .

I felt in my pocket for some change to pay for the beer, and suddenly had "the idea"—a pile of coins! Rushing back to the lab, I locked myself in the balance room and emptied my pockets of small change. I finally had the kilopascal backed into a corner; I would soon know what he felt like.

A few weighings later I had the answer—the humble penny. My pressure formula told me that a pile of nine pennies would press down with 1.01 kilopascal: in all my striving and stalking, this was the nearest I'd got to him. So let the physicists speak of their kilonewtons per square metre, I remain unimpressed. I've tracked the kilopascal to his lair: from now on he's a mere nine-pennyworths of pressure to me!

At home with the kilopascal

For the most part, the worldwide conversion to SI metric units has posed few problems for chemists. The base units of the "kilogram" and "litre" have been routinely used in laboratory measurements for many years. For these units, the changeover to the SI system has caused barely a ripple. Not so for the "kilopascal". Although it is a logical unit for pressure in the SI system (the pressure exerted by a force of one kilonewton acting upon an area of one square metre), the kilopascal is almost entirely unknown.

Learning to live with the kilopascal has not been easy. It is one thing to recalibrate old instruments to measure pressures in kilopascals, but much more difficult to re-orient one's thinking to understand what such measurements really mean. One biochemist (Dr. Bernard Brown of Manchester University Medical School, in the UK) described his efforts to understand the kilopascal in the July 1981 issue of *Biochemical Education*. Here, with his permission, we present an abridged account of his frustrating encounter, and ultimate acceptance, of the kilopascal.

Casting a furtive glance around the lab, I placed my mug of coffee on the one-pan balance and carefully noted its weight. I was just about to remove it when I heard a footstep behind me, and with a sinking feeling I realized that a colleague had discovered me.

"Why are you weighing that mug of coffee?" he asked, "Are you on a strict diet, or something?"

I decided that there was no point in hiding what I was up to. "Oh no," I said, "I'm trying to get on better terms with the kilopascal."

He looked puzzled, so I explained further. "I think it's about time that these SI units were nudged out of hiding, and revealed for what they really are; in terms that everyone can understand."

He was backing away from me now, a startled look in his eyes, but I was warming to the subject so I continued. "I've already tamed the kilojoule," I announced proudly, "the kilojoule will lift an elephant an inch. Did you know that?"

He didn't. Judging by the worried look on his face I don't think he cared very much. He suddenly remembered a distillation that he'd left on at the other end of the building, and left the lab with what can only be described as undignified haste.

With a shrug I returned to my office and prepared to do "the calculation". But first I had to drink the coffee because I needed to take measurements of the bottom of my mug. Still, the coffee gave me an opportunity to pause, and to review my progress so far in the quest.

How big was the kilopascal? This was the question I wanted to answer. It was no use tell-

ing me that, as I sat drinking my coffee, I was continually being subjected to an atmospheric pressure of about 100 kilopascals. Likewise, it was no use telling me that, if applied to a barometer of mercury, the kilopascal could support a column of this rather dense silvery liquid a whole 7.5006 millimetres high, for this seemed far removed from everyday living. I was accustomed to seeing mercury safely sealed in thermometer tubes, and consequently had no idea how hard—or easy—it was to persuade it into a 7.5006 millimetre-high column. Yet these were the only two attempts I could find to picture the kilopascal.

My mind wandered back to secondary school physics. The kilopascal, I knew, was a unit of *pressure* and elementary physics told me that pressure was the force per unit area between two surfaces in contact. Fair enough. So to find pressure, all I had to do was to measure the force, measure the area over which it acted, then divide one by the other. Now for the tricky bit—units! If the force was in newtons, and the area was in square metres, then the pressure came out in newtons per square metre—or pascals. Divide the answer by 1000 and, hey presto, kilopascals appeared!

Having buried all the theory in a formula, I set out to find how big the kilopascal was. But where was I to start? Having no concept at all of his size, I had decided to use myself as an experimental subject. That morning my bathroom scales had told me that I weighed 80 kilograms, complete with raincoat and size nine boots! Thus I was held on the earth by a force

(continued on p. 27)

Chemistry International

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to co-operate with other international organizations which deal with topics of a chemical nature;

to contribute to the advancement of pure and applied chemistry in all its aspects.

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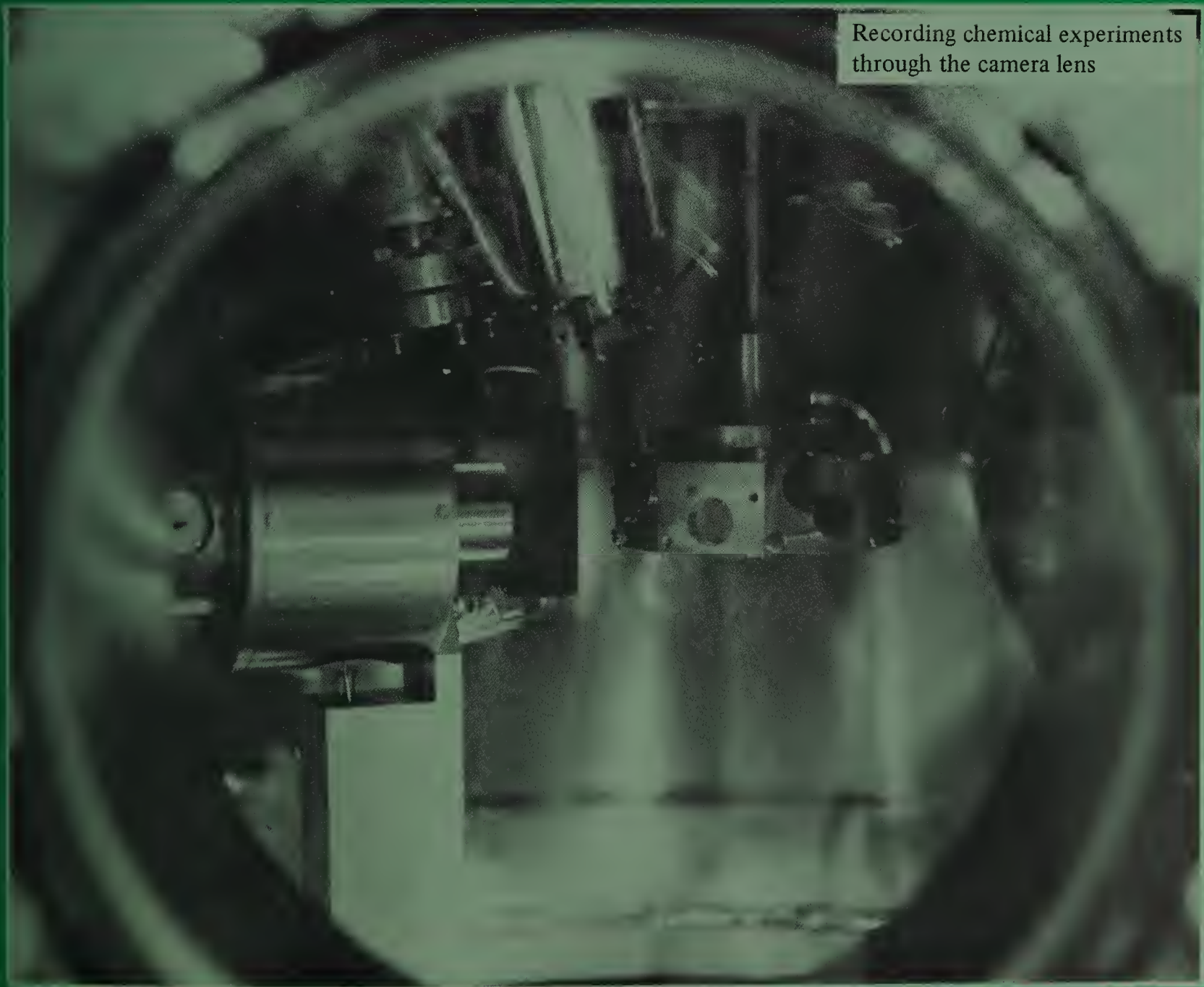
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Chemistry International

The news magazine of the International Union
of Pure and Applied Chemistry (IUPAC)



Recording chemical experiments
through the camera lens



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Good prospects reported for major advances in Atomic Absorption/Emission Spectroscopy

Atomic absorption spectroscopy has become universally accepted for analyzing low concentrations of metal ions. The advantages of the technique over classical methods of analysis were recognized soon after it was developed in the 1950's (at CSIRO in Australia). It is an extremely versatile type of spectroscopy (applicable to the determination of 67 elements usually at part-per-million concentrations), easily performed, and requires reasonably simple and inexpensive equipment.

Atomic absorption spectroscopy has become such an accepted and well-established technique of trace analysis, that most of the main instrumental problems were solved long ago. For well over a decade, the technology of atomic absorption spectroscopy had reached a plateau. Available instruments were able to provide more than adequate sensitivity to meet existing requirements for elemental analysis, and few major efforts were undertaken to extend the capabilities of atomic absorption and emission instruments.

In fact, when Sir Alan Walsh (the pioneer who developed atomic absorption spectroscopy) addressed a Discussion Meeting* of the Royal Society, he decided *not* to entitle his talk "Recent advances in atomic absorption spectroscopy", as originally suggested by the meeting organizers, because he felt there had been so few major advances within the last 15 years. Perhaps there had been little motivation to improve atomic absorption spectroscopy, as it had been so superior to other methods of elemental analysis. However, with rapid improvements in other analytical techniques (ion-selective electrodes, for example), the pre-eminence of atomic absorption spectroscopy for elemental analysis is being challenged. Furthermore, the increasingly stringent demands of analytical chemists for high selectivity, rapid analysis and ease of operation are also creating an impetus for instrumental improvement.

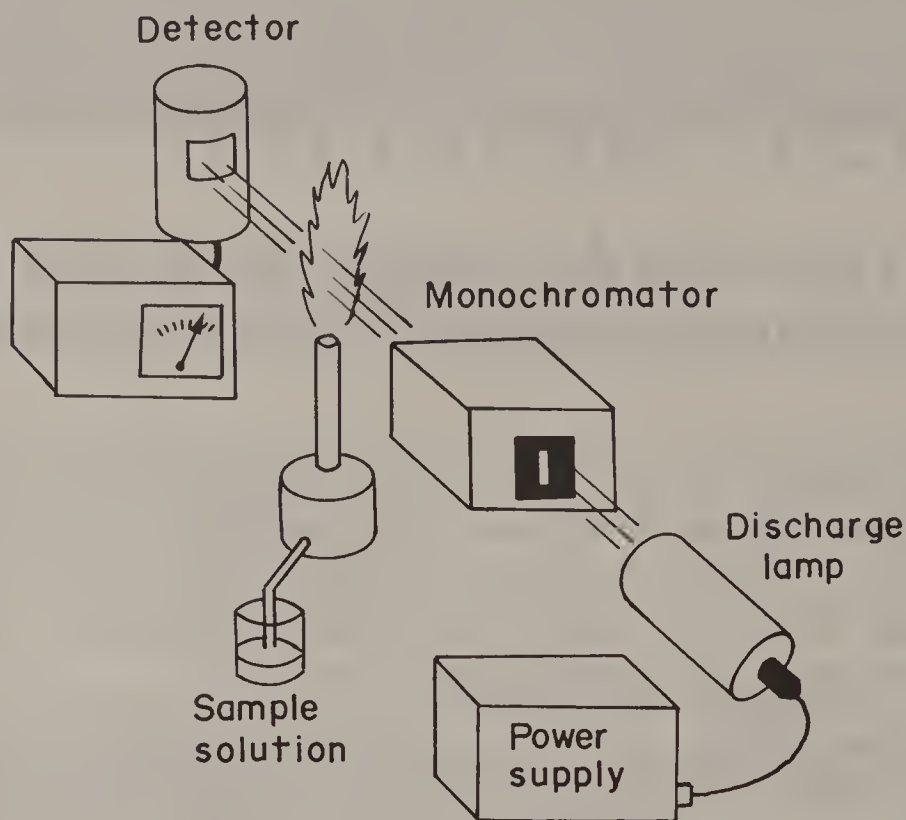
After a long period of technological quiescence, atomic absorption spectroscopy may soon be carried forward by a series of innovative developments. These innovations are more fundamental than the application of microprocessor control, such as is being carried out on a wide range of analytical instruments. They extend to the very core of the atomic absorption spectrometer, the flame in which the sample is vaporized and dissociated into atoms.

These absorb a beam of monochromatic light emitted by a low pressure discharge tube (in which atoms of the same element are excited by an electrical discharge). Absorption of the resonance radiation by atoms in the flame causes a readily-observed reduction in light intensity reaching the detector.

Injecting fine droplets of sample solution into an air/acetylene flame is a relatively simple, but inefficient, method to atomize the sample. Only about 10% of the sample solution forms droplets that are sufficiently small to be aspirated into the flame. Once formed, atoms are rapidly swept out of the flame by combustion gases. Sufficient amounts of sample solution must be aspirated to maintain a steady concentration of atoms in the flame. No major advance in flame atomization technology has been achieved since the introduction of the nitrous oxide/acetylene flame some 15 years ago.

However, one recent modification that increases sensitivity of the instrument about one hundred times is the replacement of the flame with an electrically-heated graphite furnace. A sample injected into the furnace is initially dried, then charred, and finally vaporized. Temperatures developed inside the furnace may reach 3000°C, about as hot as an acetylene/air flame. Most samples are nearly completely atomized. Since the vaporized sample is not flushed out of the furnace, as it is from a flame, the density of free atoms accumulates to a much higher level. The concentration of atoms in the vapour initially increases as the sample is heated, and then diminishes as sample vapour gradually escapes. The transient build-up of atoms in the furnace causes a sharp decrease in the light intensity transmitted to the detector, from which the concentration of the sample may be determined.

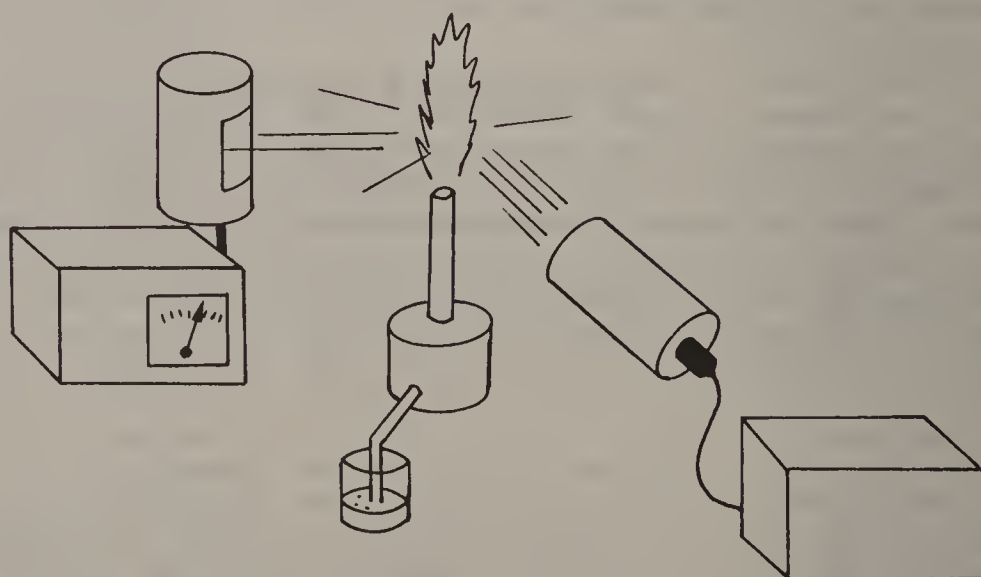
It might be possible to achieve much higher sensitivity in a conventional atomic emission spectrometer by releasing a similar short "burst" of atoms into a flame. A novel and extremely simple way to achieve this effect was described during one of the discussion periods by Dr. Tom West, Past-President of IUPAC's Analytical Chemistry Division and one of the organizers of the Discussion Meeting. He explained that atoms produced in a flame could be condensed, collected and preconcentrated on the surface of a water-cooled silica tube. Atoms are collected on the tube for a period of seconds



In an atomic absorption spectrometer (depicted on left), a monochromator is used to select *one* resonance radiation line produced by a hollow cathode gas discharge tube. The discharge tube contains vapour of the element being analysed, whose atoms emit radiation at characteristic wavelengths when excited by impacting electrons. The atomic emission line transmitted by the monochromator passes through a flame, into which droplets of sample solution are drawn. The high temperature in the flame vaporizes and atomizes the sample. If the vapour contains atoms of the element being analysed, the incident light beam is partially absorbed in the flame. Absorption of the incident light beam causes a decrease in light intensity reaching the detector.

The same type of analytical results can be obtained with an atomic fluorescence spectrometer (shown below). Since this instrument does not contain a monochromator, it is simpler (and potentially, much cheaper) to construct. All light wavelengths emitted by the discharge tube irradiate the flame, and atomic emission lines are absorbed by sample atoms. The excited atoms release their excitation energy as photons of fluorescent radiation. The intensity of fluorescence is proportional to the concentration of that element in the aspirated sample solution.

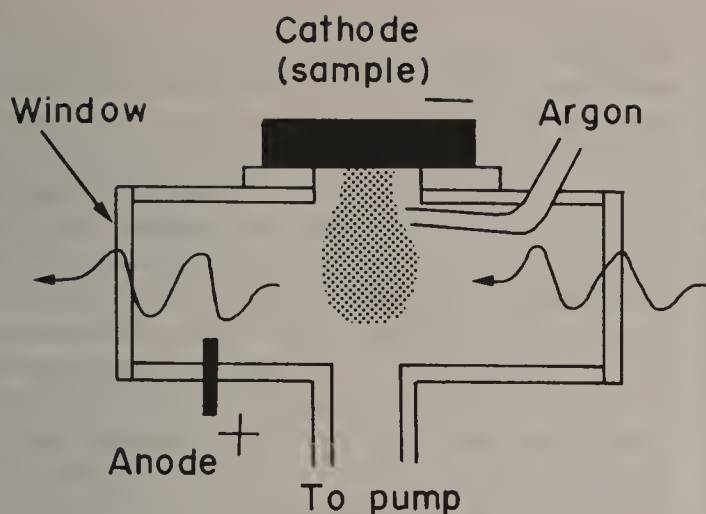
Since fluorescent radiation is emitted in all directions, only a small fraction strikes the light detector and is measured. However, the sensitivity that can be achieved is at least as high as that obtained by atomic absorption spectroscopy, since the signal is not superimposed on a large background (the incident light beam). Both techniques monitor, directly or indirectly, light radiation emitted by the discharge tube and absorbed by atoms in the flame. In order to make the light detector "blind" to light emission by atoms in the flame, the power supply voltage of the discharge tube is pulsed, and only that component of the detected signal alternating at the same frequency is amplified.



or minutes, until the flow of cooling water is interrupted. Then, rapid heating of the tube surface causes the adsorbed atoms to be released suddenly into the flame. The momentary high concentration of liberated atoms leads to a strong absorption of the monitoring light beam passing through the flame gases immediately above the surface of the tube. By mounting a silica tube in the flame and modifying the instrument detection system (to measure the brief dip in transmitted light intensity, rather than a

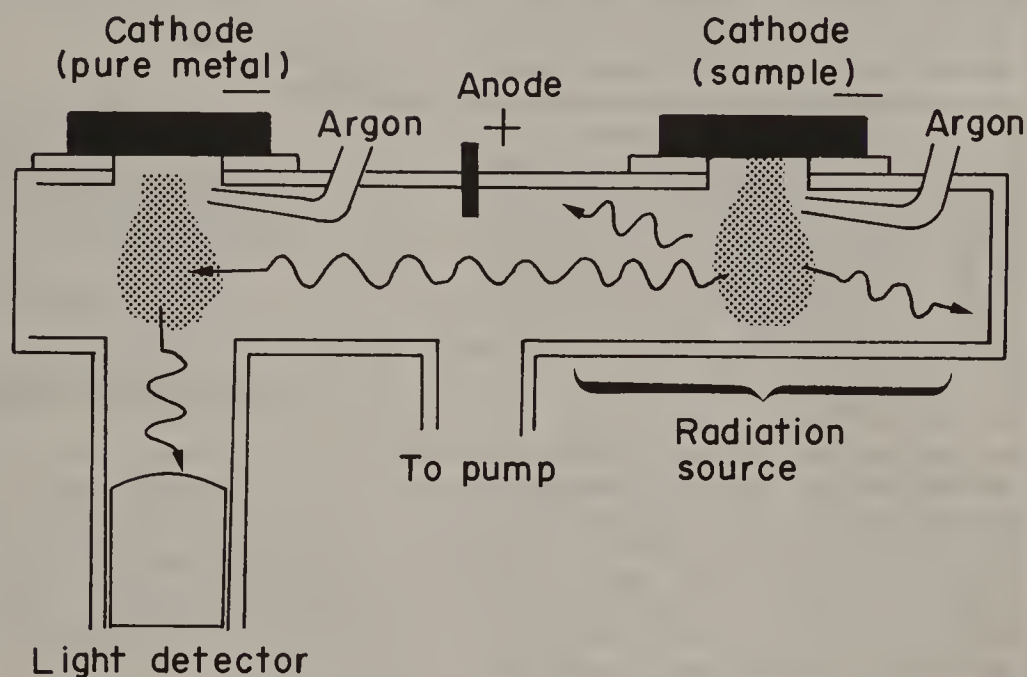
steady-state intensity), it should be possible to detect many elements at much lower concentrations. In most cases, the sensitivity is about 100 times greater than with normal flame techniques. The technique appears to be applicable in the determination of most elements (a few, like mercury, are too volatile to be condensed on the silica tube).

If such simple modifications prove effective, they might delay—but will probably not halt—the introduction of radically new com-



In a sputtering cell, atoms are ejected directly from the surface of a solid sample by bombardment with argon ions. The sample, which is made electrically conductive, serves as the cathode of an electrical discharge. The gas pressure in the sputtering cell is much lower than in a flame or furnace, so atomic absorption linewidths are extremely narrow. Different isotopes of the same element can often be distinguished. Windows at each end of the cell allow the monitoring beam to pass through the cloud of sputtered atoms.

Normally, the sputtering cell is a discrete component which replaces the burner head in a conventional atomic absorbance spectrometer. By altering discharge conditions, it is possible to enhance electrical excitation of sputtered sample atoms and use the sputtering cell as a radiation source. The radiation source and another sputtering cell can then be integrated into one windowless discharge tube, containing all the main components of an atomic fluorescence spectrometer (whose operation is depicted in this conceptualized drawing). This spectrometer unit could utilize atomic absorption/emission lines in the vacuum ultraviolet that are strongly absorbed by air.



ponents and designs for atomic absorption spectrometers. Notable among these is the Inductively-Coupled radiofrequency Plasma discharge (ICP). This device, in the view of Prof. R. M. Barnes (of the University of Massachusetts) could become universally accepted as a spectrochemical source. An ICP discharge might not only replace the flame of an atomic absorption spectrometer as a source of atoms, but could also be used as an atomic emission light source to replace conventional discharge tubes.

Prof. Barnes' lecture dispelled the commonly-held notion that ICP's are very sophisticated devices to be used only for specialized applications. It is true that processes occurring in the discharge have been poorly understood, and this has been a major factor inhibiting its widespread acceptance. However, recent experiments have divulged much useful information about the nature of the inductively-coupled r.f. plasma. In fact, Prof. Barnes speculated that the reactions occurring in the ICP discharge could prove simpler than the processes in a flame, and projected that the

ICP discharge might become the first spectrochemical source to be completely understood. Already, there is growing confidence in the use of inductively-coupled plasmas as excitation sources and atom sources for atomic absorption and emission spectroscopy, atomic and molecular fluorescence spectroscopy, and mass spectrometry. The number of research papers describing analysis methods using ICP discharges has been growing at an exponential rate, and about 1000 plasma discharge instruments are now in operation throughout the world.

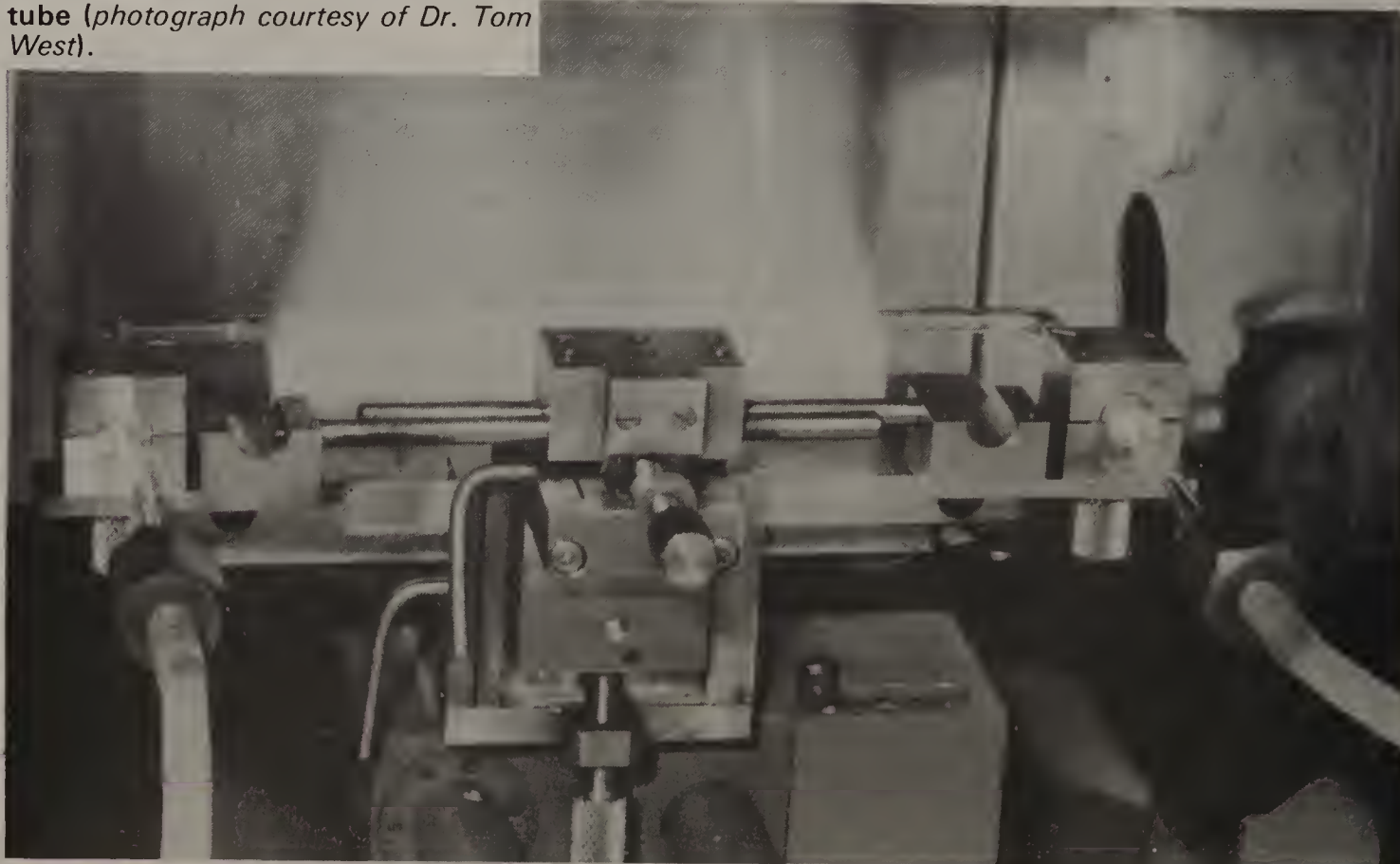
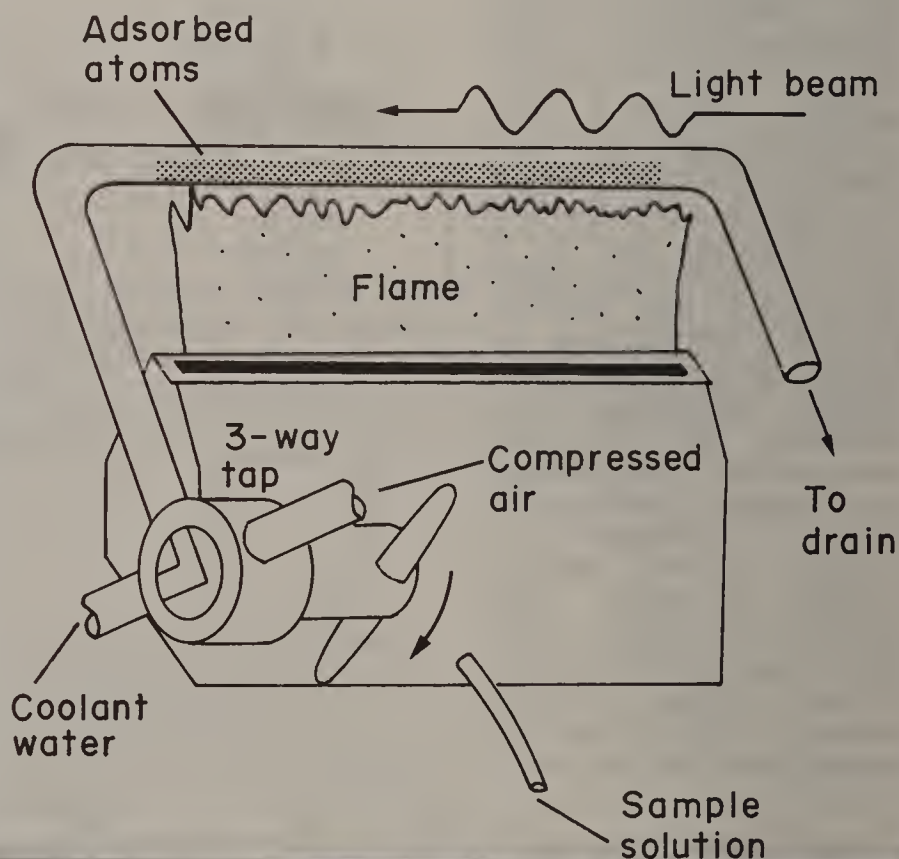
Sample solution is carried into an ICP discharge as fine droplets in a flow of atmospheric-pressure argon gas. The aerosol mixture flows through a silica tube within a coil, to which is applied a radiofrequency (20 - 50 MHz) voltage. A radiofrequency electric field is induced within the gas, heating and partially ionizing the argon. The main glow of the discharge occurs within the radiofrequency coil, but characteristic light radiation is emitted by sample atoms in a clearly separate "emission observation zone" beyond the main plasma

discharge. Evidently, some of the radio-frequency energy pumped into the discharge is stored by excited metastable argon atoms. These are swept beyond the main glow, where they excite atoms from the sample solution.

An ICP discharge could overcome some inherent limitations of a flame atomizer. For one thing, a conventional atomic absorption spectrometer can analyze only one element at a time. The possibility of simultaneous multi-element analysis is essentially ruled out, since separate radiation sources are required for each element to be analyzed. Furthermore, different flame conditions may be required to achieve optimal sensitivity for each element. By con-

trast, one set of ICP discharge conditions will produce excited atoms in all elements to be analyzed. Thus, ICP offers the capability to analyze many elements simultaneously, thereby reducing the amount of sample and analysis time required. ICP also offers the advantages of high sensitivity, linear response over a very large range of sample concentration, and low emission of background radiation. On the other hand, ICP discharges will likely continue to be costly to install and complicated to operate, despite indications that its construction and use could be considerably simplified (perhaps by utilizing nitrogen or air, instead of argon). Furthermore, an experienced spectroscopist is re-

Sensitivity of an atomic absorption spectrometer can be greatly increased by trapping atoms on the surface of a water-cooled silica tube mounted in the air/acetylene flame. When enough sample atoms have been collected on the surface to provide a strong signal (after a period as long as several minutes), cooling water is blown from the tube by a jet of air. Adsorbed atoms are vaporized almost immediately by the 3000° combustion gases (some atoms may be ejected by impact of excited radicals on the tube surface). The rapid release of the absorbing atoms causes a sudden drop in intensity of the monitoring light beam, which passes through the region immediately above the tube. The position of the tube in the flame is carefully controlled (by adjusting the mechanism seen in the photograph) to achieve optimal sensitivity. The very small thermal expansion of silica allows the tube to resist repeated shocks produced when cold water flows into the red-hot tube (*photograph courtesy of Dr. Tom West*).



quired to operate an ICP-equipped instrument. No simple preparation procedure has yet been found which is suitable for all types of samples.

Another way to produce atoms is by sputtering—by ejecting atoms directly from the surface of solid samples. In this method, a solid sample is utilized as the cathode of a low-pressure gas discharge, and is bombarded by argon or other noble gas ions. Sputtering appears particularly suited for analysis of ores and metallurgical samples. It allows the sample to be analyzed *directly*, without initially dissolving the sample or using other wet chemical preparation methods. The possibility of contamination is therefore reduced, although the sensitivity achieved by sputtering the sample is not as high as with conventional flame atomic absorption. The technique is still in its infancy, and considerable improvement may be attained after further development.

One potentially important application for a sputtering atom source is the determination of the isotopic composition of a sample. Isotopes of some elements (particularly elements of low atomic weight) absorb or emit radiation at slightly different wavelengths, providing a means for selectively analyzing each isotope. In a flame or plasma discharge at atmospheric pressure, the relatively high pressure of the gas broadens the absorption lines of the isotopes (which intrinsically have an extremely narrow spectral bandwidth), and causes them to overlap. However, broadening of atomic absorption lines is not significant in a sputtering cell, in which a low-pressure gas sustains the electrical discharge for ion bombardment of the sample.

Not all recent developments in atomic absorption instruments are intended to achieve high sensitivity or greater versatility at the expense of simplicity. On the contrary. One of the most interesting developments described at the meeting was a very simple, low-cost atomic fluorescence instrument for measuring elemental concentrations in solution. Like a conventional atomic absorption spectrometer, it employs a low-pressure discharge tube to emit radiation at characteristic wavelengths. The radiation is partially absorbed by a flame, into which atoms of sample solution are aspirated. Each atom that absorbs an incident light photon must soon release its excitation energy, which it does by emitting a photon of fluorescent radiation. In an atomic fluorescence spectrometer, the light detector is placed to the side of the flame, usually perpendicular to the path of the incident light beam. The fluorescence intensity provides an indirect measure of light absorption by atoms in the flame, and is proportional (at low concentration) to the sample concentration of the element being analyzed.

The measurement of atomic fluorescence offers several significant advantages. For one thing, it is inherently simpler to detect the appearance of a small light signal (due to

fluorescence), rather than a decrease in intensity (due to absorption) of a relatively intense light beam. It is not essential that a fluorescence spectrometer contain a monochromator, one of the most costly and complex components of an atomic absorption spectrometer.

The low-resolution monochromator used for atomic absorption measurements functions as a "spectral window", transmitting a selected atomic emission line emitted by the discharge tube. It filters out background radiation emitted by inert gas or ionized atoms in the gas discharge. This radiation is not absorbed by sample atoms in the flame. Without filtering, this radiation would contribute a large background signal in the detector output, whose random fluctuations ("noise") would obscure the small decrease in light intensity due to atomic absorption. Since this extraneous radiation is not absorbed by sample atoms in the flame, it does not induce fluorescence. Thus, a fluorescence spectrometer does not require a monochromator to filter extraneous radiation emitted by the discharge tube. However, some background radiation is emitted by the flame itself. Consequently, simple "non-dispersive" fluorescence spectrometers (which do not have a monochromator) must utilize a less sensitive "solar-blind" detector.

Elemental analysis by atomic fluorescence is also prone to interference when the sample contains metals (like aluminium) that form refractory oxides in the flame. Particles of these oxides scatter the incident light beam. Some of the scattered light reaches the detector, giving rise to a large background signal and significantly reducing the sensitivity of the analysis (refractory metal oxides would also reduce the sensitivity of analysis with atomic absorption spectroscopy, but evidently to a lesser extent). Pre-treatment of the sample or use of a more sophisticated detection system might reduce or eliminate the effect of scattering, but these methods would sacrifice the great advantage of atomic fluorescence spectroscopy—its simplicity. A more fruitful approach might be to utilize simple non-dispersive atomic fluorescence spectrometers for specific applications in which refractory metal ions are not normally present in the sample solution. There are a number of important analytical applications for which atomic fluorescence could be readily applied, and one might envisage the introduction of low-cost "dedicated" instruments for the analysis of a few elements in particular types of samples.

** Discussion meeting on "Recent Advances in Analytical Chemistry", held at the Royal Society (London) on 9 - 10 December 1981. Proceeding will be published by the Royal Society, 6 Carlton House Terrace, London SW1Y 5AG.*

Chemical analysis through the electron microscope

The electron microscope is increasingly being utilized to probe the chemical composition of microscopic samples. With relatively little modification of an existing electron microscope, the instrument can simultaneously provide structural and chemical information. This capability opens a new dimension in electron microscopy, allowing the operator to investigate changes in chemical composition associated with microscopic structural features of the specimen.

Three techniques used to determine chemical composition in the analytical electron microscope were outlined by Dr. R. F. Egerton (from the University of Alberta, Canada) at the Royal Society Discussion Meeting on "Recent advances in analytical chemistry". In each method, the microscope's high-energy (100 000 eV) electron beam is focused to a small spot on the sample specimen, and the electron beam is swept across the sample. The incident beam ejects electrons from inner-shell orbitals of atoms in the sample. Each resulting deep-lying "hole" is subsequently filled when a valence electron falls into the void. In order to undergo this transition, the atom must dissipate the substantial energy difference between the two orbital levels.

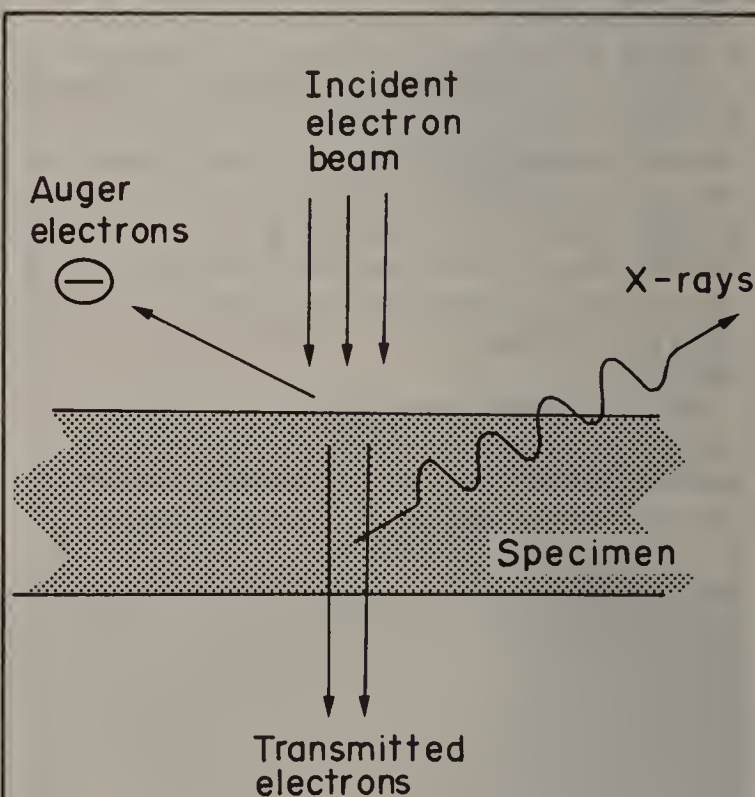
One way that an atom can dissipate this energy is by emitting a photon of x-ray radiation. The energy of the emitted x-ray photon reflects the energy difference between the valence and inner-shell orbitals, and is characteristic of that particular element.

X-ray photons emitted by various elements in a sample usually have sufficiently different energies to be distinguished by a lithium-drifted x-ray detector. The resolution provided by this semiconductor device is rather limited (it can only distinguish two photons if their energies differ by at least 135 eV), but is usually adequate to identify the main constituent elements present at each point in the sample. The x-ray detector is mounted directly above the specimen platform of the electron microscope. Installation of the detector does not require major modification of the instrument.

X-ray emission is the most probable outcome when a heavy atom is excited by electron impact. Light elements generally dissipate excitation energy through an alternative mechanism. Once again, ejection of an inner-shell electron leaves a deep-lying "hole". As a valence electron plunges into the atomic abyss left by the partially empty inner-shell orbital, energy is released. This is expended by ejecting a second electron from the atom, this one from an outerlying valence orbital. The kinetic energy imparted to this "Auger" electron is determined by the energies of the inner-shell and valence orbitals. This energy is, once again, characteristic of the particular element. The composition of the sample can thus be

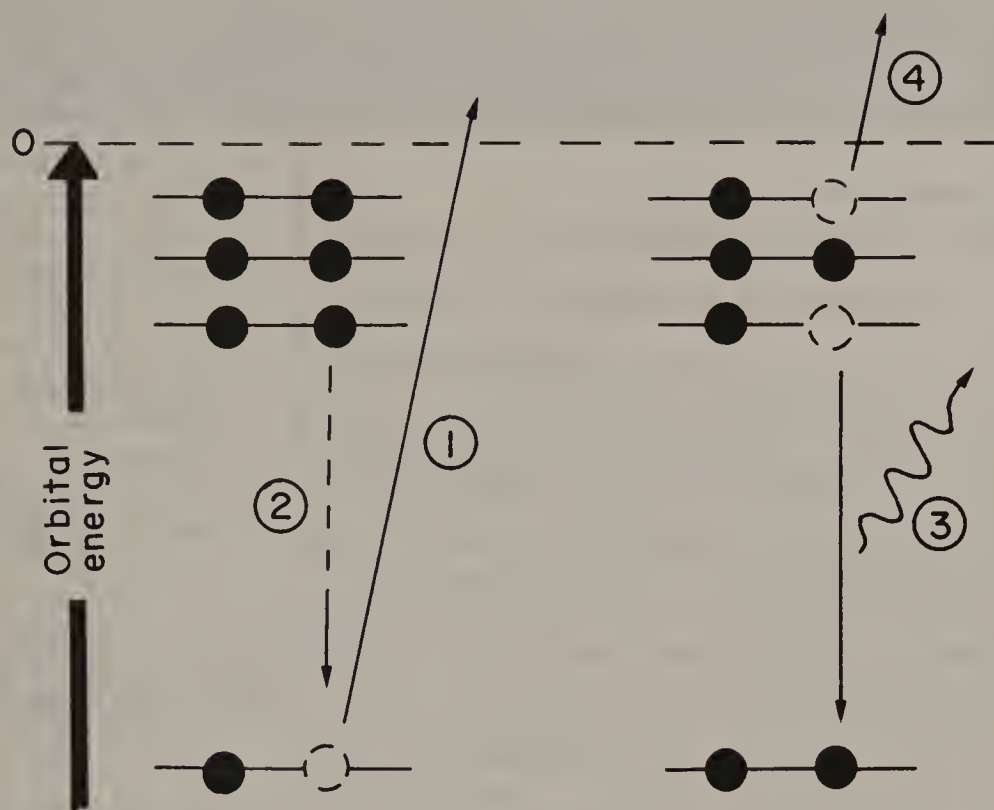
determined by measuring the energy distribution of the Auger electrons. However, only Auger electrons ejected from surface atoms are detected. Electrons—unlike x-rays—can travel only short distances within the sample, and only those originating within about one nanometer of the surface can escape. Thus, measuring the energy of Auger electrons provides an excellent means of analyzing the composition of atoms on the *surface*.

Of course, in some studies the analyst might wish to determine the chemical composition of the bulk material, without restricting his analysis to heavy elements. Then, the desired information can be



The chemical composition at each point in a microscopic sample can be determined by exciting its constituent atoms with the highly-focused beam of an electron microscope. Each element emits X-ray photons, whose characteristic energies can be measured by an X-ray detector mounted above the sample platform. X-ray emission is efficient only in atoms of heavy elements; lighter elements usually release their excitation energy by ejecting "Auger" electrons. An electron ejected from a surface atom can escape from the sample, carrying with it a kinetic energy that is characteristic of the element from which it originated. A third method that can be used to identify sample atoms is by measuring the kinetic energy of electrons transmitted through the sample. The energy lost by an electron in passing through a sample indicates the ionization potential (and thus, the identity) of the atom which it ionized.

When a high-energy electron strikes an atom, an electron can be ejected from a low-energy inner-shell orbital (1). The resulting "hole" will be filled by a valence electron (2). However, in order for the atom to undergo this transition, it must release the energy difference between the two orbital levels. There are two alternative ways for the atom to do this. If it is a heavy element, it will most likely emit a photon of X-ray radiation (3). The energy of the photon reflects the atomic levels involved in the transition, and is characteristic of that element. For light elements, the most likely event is the ejection of an Auger electron from the valence band of the atom (4). In this case, the amount of kinetic energy conveyed to the electron is determined by the orbital energies of the atom from which it originated.



obtained by measuring the energy of electrons transmitted through the sample. Most electrons impinging upon the sample do not collide with any atoms, and emerge with the same energy as electrons in the incident beam. Those that *do* excite a sample atom leave the specimen with less kinetic energy. The amount of energy lost by an electron is exactly the amount required to excite the particular sample atom. Thus, the energy-loss spectrum of transmitted electrons is an elemental fingerprint of the sample.

An electron energy-loss spectrometer can be mounted directly beneath the specimen holder of an electron microscope, without impairing normal operation of the instrument. The analyst can observe the microscopic structure of the sample, and then see

how the location of structural features correlates with the distribution of particular elements. The energy-loss spectrometer could be adjusted to transmit electrons scattered from calcium atoms, for example. Then, as the electron beam is scanned across the sample, a map of calcium concentration is compiled (and then compared with the normal electron micrograph of the sample). Local concentrations of the element can be pinpointed with a spatial resolution of about one nanometer. The energy-loss method is capable of high sensitivity; being able to detect trace amounts (but not trace concentrations) of various elements. With elements of low atomic number, as little as 10^{-20} grams can be detected.

A massive problem with atomic weights

My reading, during a post-sabbatical catch-up, of the note in *Chemistry International* (1980, No.4, pp. 9 - 10) about "atomic weight" terminology has prompted me to express some long-held opinions on the subject.

"Atomic weight" is indeed a bothersome term and should be eliminated; it is very difficult to justify retention of "weight" in the context of SI. "Relative atomic mass" is an accurate term but, it seems to me, unnecessarily cumbersome. If the atomic mass unit (u) is defined as 1/12 the mass of an atom of the nuclide ^{12}C (as in NBS Spec. Publication 330 and in ISO/R 31/VIII, IX), why do we need to retain "relative"? Why not use the simple name "atomic mass"? The unit used with atomic mass *could* be g or kg, but would ordinarily be u. One would obtain directly from the periodic table, for example, the value 1.008 u for the *atomic mass* of H; would infer that the *molecular mass* of H_2 is 2.016 u; and would further infer that the *molar mass* of H_2 is 2.016 g and of H, 1.008 g.

Reference to the "atomic mass" of an element, *without specifying a particular nuclide and without other qualifiers/modifiers*, should indicate the effective atomic mass (in u) of the element, obtained by averaging the isotopic compositions "found in nature". If the variation of isotopic composition from sample to sample is under discussion, phrases such as "atomic mass of X in sample z", or "the sample atomic mass" should be clear in that context.

It does not seem reasonable to me that we should continue with "atomic weight" and "relative atomic mass" when we have available, for use *with* SI, a perfectly good mass unit (u) which was, in fact, invented for precisely this use.

Prof. Robert D. Freeman
IUPAC Commission on Thermodynamics
Oklahoma State University (USA)

The Editor comments:

The phrase "molar mass" seems a very appropriate term that could circumvent the controversy about "atomic weight" versus "atomic mass". Since only chemists use moles, there is no possibility that this would confuse physicists. Furthermore, it would be quite evident what "molar mass" means to a chemist encountering it for the first time. And finally, since "molar mass" is the mass of one mole, there would be no doubt that it would have units of grams. One would not need to replace "atomic weight", but by dealing on a molar level, the terms "atomic weight" and "molecular weight" would gradually fade from use.

Prof. Freeman's reply:

I don't agree that "molar mass" can eliminate the need for something to replace "atomic weight" and "molecular weight". We can not always express our ideas at the molar level; we must be able to speak/write precisely about phenomena at the atomic/molecular level. That includes precise description of the masses of atoms and molecules; "atomic mass" and "molecular mass" are *needed*. The point is that "atomic weight" is inaccurate and "relative atomic mass" is cumbersome and confusing to students. "Atomic mass", "molecular mass", "ionic mass", etc. are simple, straightforward, and precise.

Prof. Norman Holden* responds:

The International Commission on Atomic Weights (ICAW) has been working on the name and/or definition of "atomic weight" continually since the late 1960's. In recent years, the ICAW has held a joint meeting in 1979 of all IUPAC Commissions interested in terminology; I represented the Commission at these meetings. The subject for discussion at each meeting was either wholly or in part the name "atomic weight". The consensus from the above discussions was that the phrase "atomic weight (mean relative atomic mass)" should be retained for the concept. It was argued that "atomic weight" is a well-established term with a definite meaning which has been used by chemists for almost 200 years without giving rise to any confusion. The alternative "relative atomic mass" might be confused with the atomic mass of a single nuclidic species. If "atomic weight" should be abandoned, it should be replaced by a term which indicates that it is actually a pure number.

Your proposal is one of many which has been made in a sincere effort to eliminate the noun "weight" from the concept because of possible confusion between "weight" and "mass" in the minds of beginning students. However, there is no rule in that any term consisting of a noun modified by an adjective must have the dimensions of the noun. Consider the well-accepted concepts specific weight, dipole moment, resolving power, electromotive force and relative atomic mass. None of these terms have the dimensions of the noun that is modified.

On the subject of the term "molar mass," the Commission considered and rejected it in the 1950's because the term molar implies concentration and not quantity. It was later proposed by J. C. Rigg of the Commission on Quantities and Units (of the Clinical Chemistry Division). IDCNS discussed it briefly in 1979 and stated that it is a quantity of a different dimension and is not involved as to the merits of "atomic weight" compared with "atomic mass." This is not a proposal for a name change, but a

change in the concept to an absolute mass which just happens to have the same numerical value as the present atomic weight.

After so many years of discussion, I thought that the subject had been laid to rest for a while, until I received your letter. As a member of IUPAC, you can appreciate that members of the ICAW volunteer their spare time to Commission work and I am reluctant to begin another ten or fifteen years of discussion, which takes valuable time from more important items on the ICAW agenda.

**Professor Holden is Chairman of the Commission on Atomic Weights and Isotopic Abundances.*

Can chemical technology offset population growth?

The editorial by Bryant Rossiter in your December issue (A chemist's "call-to-arms") gives tacit approval to the view that world hunger is not due to overpopulation. I consider *Chemistry International* to be a responsible and important publication; therefore I am horrified to realise that you may be technologically bigoted. How do you imagine Japan would cope if she were not allowed to import food?

One of the basic requirements for a stable ecosystem is that none of its species should over-run its food supply. Considering our planet as a closed ecosystem (which it is), one species has already over-run its natural ecological level. Until this fact has been grasped by mankind in general, nature will continue to use its own, very unpleasant methods of control (including war). We must reach a compromise with nature.

Mr. P. Sebell, UK

Editor's comments:

I published Dr. Rossiter's statement because I felt it made some valid arguments, and expressed some important ideas that are usually overlooked. I don't think he is saying that overpopulation isn't ultimately the major cause of hunger. In the long-run and on a global level, it almost certainly will be and I echoed this sentiment in an article discussing "Industrial growth vs population growth" published in

RECENT REPORTS

Glossary of Terms used in Nuclear Analytical Chemistry (Provisional)

This glossary lists close to 400 terms and definitions commonly used in radiochemistry, with emphasis on radioanalytical chemistry. The report is prepared under responsibility of IUPAC Commission V.7 on "Radioanalytical Chemistry and Nuclear Materials". It is adopted by IUPAC as a provisional document. Part of the definitions have been taken, sometimes with minor modifications, from existing glossaries of, i.e. the I.S.O. and the I.E.C. In cases where no acceptable definition could be found, a new definition is proposed.

The report is expected to be published in *Pure & Applied Chemistry* in mid-1982.

Chemistry International, 1981, No.4. However, in most countries where malnutrition and starvation are now acute problems, overpopulation does not appear to be the immediate cause.

If we look at each country as a closed ecosystem, as you suggest, then Singapore should have a population of less than a few thousand. Yet, this tiny island maintains a population of several million people in a state of good nutrition and relative affluence. It can do this because it is not a closed ecosystem in biological equilibrium, but an open port in economic equilibrium with Southeast Asia, North America and Western Europe.

To say that overpopulation is the cause of hunger (or war) would seem to be a blatant oversimplification. An obvious and immediate threat to our survival seems to be nuclear war. Yet, the major nuclear powers have relatively low population densities and high agricultural output. Perhaps even before we attempt a compromise with nature, we should come to terms with ourselves.

Photography in the laboratory

Photographs provide a unique way of presenting information. They show—at a glance—how an experiment was performed or the type of sample being investigated. Photographs can be a useful reference source in the experimenter's laboratory notebook. They can also convey meaning and perspective to a lecture, crystallizing the information contained in numerous tables and graphs into a clear visual image. Yet, the value of photographs as a means for recording and presenting technical information is often overlooked.

Photographing a piece of scientific apparatus, a sample or a chemical reaction is basically no different than taking a picture of the family at a picnic. There are, however, several important differences that set apart scientific photography. For one thing, an experimenter usually wishes to show as much detail as possible. This represents a marked deviation from the approach of a skilled portrait photographer. His aim is not to obtain an objective record, but to present a flattering or aesthetically-pleasing view. This he does by limiting the amount of detail—selectively blurring the background or foreground so that the viewer's attention is focused onto the main subject.

Keeping various parts of a chemical apparatus in sharp focus requires that the camera be adjusted to a small lens aperture. This is absolutely essential in close-up photography, when the specimen or device to be photographed is very small. Use of a small aperture restricts the amount of light reaching the film—generally to about one-tenth the amount available for portrait or landscape photography. In addition, an experimental apparatus will normally be photographed in the laboratory, where light levels are typically 1000 times less than in bright sunlight.

Thus, the basic challenge of scientific photography is to obtain detailed photographs at low ambient light levels. To do this successfully, the scientist can exploit one special characteristic exhibited by most chemical apparatus and specimens: they don't move. The use of long exposure times therefore provides one simple and cheap method to deal with the special requirements of scientific photography.

A chemist need not be a highly experienced photographer, or have very sophisticated equipment, to obtain good-quality photographs of his experimental apparatus. Recent technological advances have greatly extended the versatility of cameras and accessories that are available at very reasonable prices. Most chemists who own a 35 mm camera will find that it can easily be adapted for use in the laboratory. This article explores a few simple techniques, and their underlying physical principles, to help chemists use their camera for recording their experimental procedures and explaining their results (and possibly, to get better pictures at the next family get-together).

1. Showing the viewer what he needs to see

Scientific photography entails presenting information: the appearance of a sample or reaction mixture, the construction of a device, or the method for carrying out an experiment. It is therefore essential that the photographer should have clearly in mind exactly what information he wishes to record. He should then choose his vantage point and camera settings to show this information in the clearest possible way. At the same time, the photographer should strive to eliminate extraneous detail that will make the photograph unnecessarily complicated and distract the viewer from the important information.

A photographer controls not only *what* the viewer will later see, but *how* he sees it. He can bias the observer's view, in much the same way as a newspaper editor can sway his readers by emphasising or obscuring certain facts. When presented with an actual scene, a person scans his eyes from object to object. For each object on which he momentarily gazes, the observer focuses his eyes at that distance. Simultaneously, he constricts or dilates his iris so that the light intensity striking his retina is optimal for viewing that object. These complex control mechanisms are carried out automatically by the viewer's brain, without his being aware that these actions are taking place.

A photograph, on the other hand, freezes the scene with only one element in perfect focus and with optimal exposure—the way the photographer had wished the scene to be viewed at the instant he released the shutter. The photographer's choice of camera settings (based on guidance provided by the camera's lightmeter) alters the appearance of the recorded image, and may dictate how a viewer will later scan the same scene.

Generally, for scientific photography, one wishes to impose relatively little restriction on the viewer, allowing him to study details of each component. This requires that all objects are in sharp focus (with the greatest possible depth-of-field), the camera does not move while the shutter is open, and that the film is correctly exposed (controlled automatically with most modern cameras). Furthermore, the film should have sufficiently fine grain to record details resolved by the camera lens. A photograph meeting these criteria can contain an enormous amount of information which can subsequently be tapped by enlarging various parts of the negative. However, any photograph will have little value unless it shows features that one would wish to see, and does not show excessive amounts of irrelevant detail ("chemical noise").

Because the scientific photographer does not usually predispose the viewer's scan towards any particular object, it is especially important that he choose a vantage point from which extraneous items do not appear. When, for example, a slide of an experimenter's ingenious new ion source is projected at a lecture, a colleague might initially fix his gaze upon the dirty ashtray lying behind the device. Hav-

ing used a long depth-of-field, the photographer has not imposed any prejudice about the relative importance of the two objects. In the same way, stained reagent bottles on the laboratory shelf, or equipment used for other experiments, distract attention from important elements in the scene but impart no useful information to the viewer. Such clutter should be eliminated from view—either by selecting a vantage point from which they are not visible, by moving them out of the way, or by moving the camera closer to the main component of interest. If the object to be photographed is portable, it can be moved onto a simple background of white or coloured paper, a white table top, or a plain carpeted or tile floor.

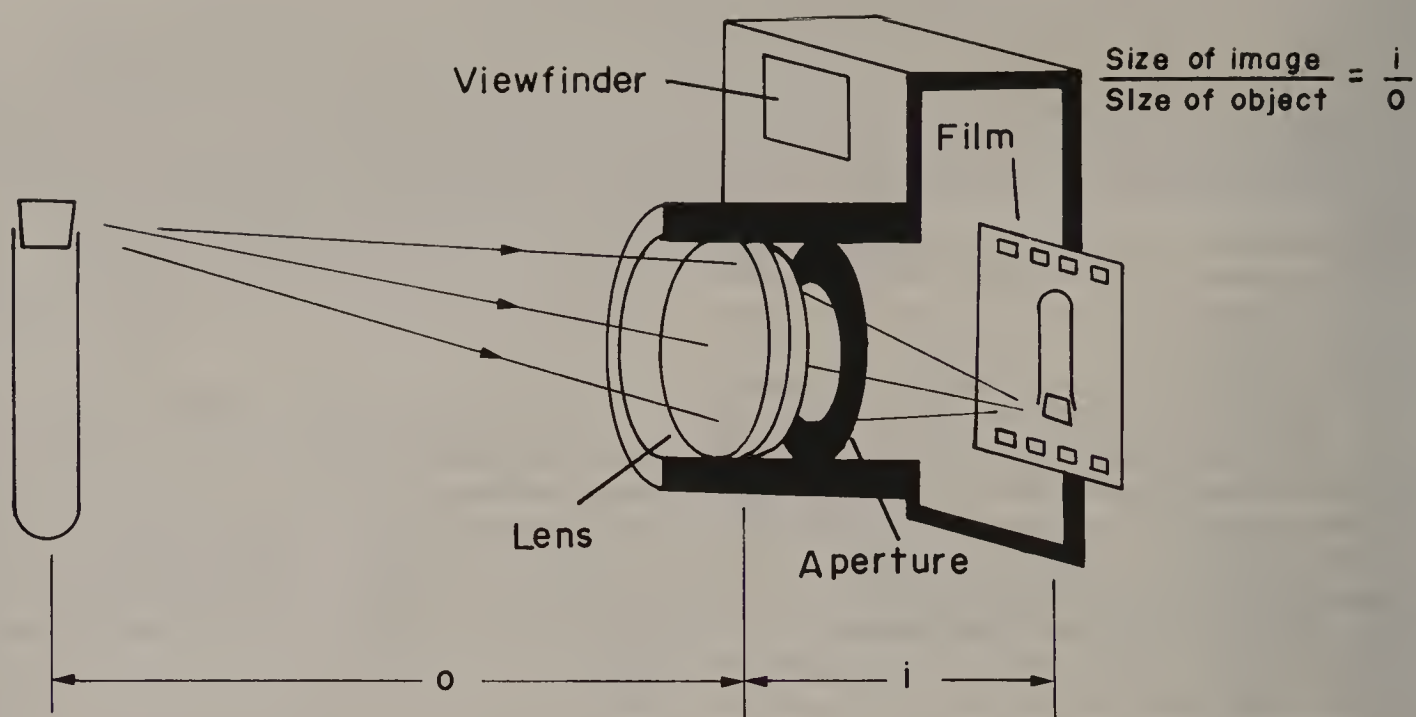
Although maximum depth-of-field is generally desirable in photographs from which detailed information can be derived, it is sometimes unnecessary. When the sample or apparatus is relatively flat, a shallow depth-of-field is adequate to show all pertinent information, and blurs irrelevant detail in the background.

Many photographs could be improved by moving the camera closer to the main object of interest. One professional photographer once recommended that novices could improve their photographs by following three simple rules: (1) move closer, (2) move closer, and (3) move closer. In short, you should get as close as you can while still retaining all the important information within the camera viewfinder. It may not, however, always be readily apparent which information might later prove valuable to yourself, or be most helpful in explaining the experiment or apparatus to others. This decision may require some thought, as well as an intimate knowledge of the subject.

2. The closer you get, the better it looks

In scientific photography, it is often necessary to obtain detailed photographs of small components or specimens. This requires the use of special techniques, since cameras equipped with standard attachments cannot focus on objects much closer than about one metre away. Even when the minimum focusing distance is as short as 600 mm (achieved by extending the camera lens forward to about 60 mm from the film), then the image on the film can be no larger than one-tenth the actual size of the object. In other words, the maximum "magnification" of a camera with a standard lens is about 0.1. Of course, the image recorded on film is enlarged when the negative is printed. A normal-size photographic print is about $3\frac{1}{2}$ times the size of a 35 mm negative. The amount of detail which can be easily observed depends on the *area* of the printed image. On a normal-size print, an object positioned at the camera's minimum focusing distance is reproduced with about one-tenth its actual area.

The simplest way to photograph small objects is to use the camera at its minimum focusing distance, and print only part of the negative with greater-than-usual enlargement. This method of "close-up"



The most important component of a camera is its lens, as seen in this simplified cutaway view of a (rangefinder) camera. The lens collects light leaving each point on the object being photographed, and focuses it onto a corresponding point on the image. The size of the image formed on the film, relative to the actual size of the object, is termed the "Magnification" (which is usually much less than one, except in close-up photography). The magnification, M , is simply the ratio of the lens-to-image distance (i) and the lens-to-object distance (o).

The camera is focused by moving the lens forward or backward so that the image is formed on the photographic film. When the object is very far, light rays striking the lens are nearly parallel. The lens should then be fully retracted so that its focal point lies in the plane of the film. Closer objects are kept in focus by projecting the lens away from the film. The distance that the lens can be extended forward determines the minimum focusing distance of the camera, which is usually about one metre (without auxillary close-up lenses or extension tubes).

Only objects located the same distance from the camera lens will be in perfect focus. However, objects will be in reasonably good focus if they are not much beyond or nearer to the camera than the plane which is in focus. Within this range, an object will lie within the camera's "depth-of-field". The photographer controls depth-of-field by dilating or constricting the aperture. This also regulates the light intensity striking the film. The amount of light focused to each area on the film is proportional to the area of the aperture. The light-gathering ability of a camera (or any optical device) is inversely related to its f -number (the ratio of the lens-to-image distance and the aperture diameter). Half the light intensity strikes the film when the aperture diameter is reduced by a factor of $2^{1/2}$ (and the f -number is increased by the same factor—say, from $f5.6$ to $f8$). The loss of light intensity is compensated by doubling the exposure time.

photography allows one to obtain prints about life-size—without purchasing any additional camera equipment. Because the negative is to be greatly enlarged, the photographer must take extra care to ensure that his focusing is accurate and the light exposure is correct. It is essential that the camera does not move during the exposure. To support the camera in the desired position, a tripod is extremely useful, but one could make do by propping the camera on a pile of books (using coins to adjust the angle of the camera). Use the camera's self-timer or a shutter release cable to prevent camera movement when the shutter is opened. With the camera supported in this way, exposure times of one second or longer can be used routinely without any problem with camera movement.

The ability to keep the camera motionless during long exposures is extremely useful. It allows the photographer to obtain correct exposure even when using a very small lens aperture to obtain maximum depth-of-field. Normally, one can constrict the aper-

ture by one f -stop (say, from $f11$ to $f16$) while doubling the exposure time (say, from $1/8$ to $1/4$ second). This maintains correct exposure of the film, since the extent of the chemical reaction at each point in the film is proportional to its *total light exposure* (Intensity $\times$ Time). The time that the shutter remains open should be reciprocally (inversely) related to the light intensity impinging on the film. This is controlled electronically when the camera is operated in its "Automatic" position. Then, the photographer selects either the lens aperture *or* the shutter speed, and the lightmeter controls the other.

There is, of course, a limit to the depth-of-field one can achieve with very dim lighting. At very low light intensities, photographic film undergoes "reciprocity failure"—the extent of the photochemical reaction is *less* than would be expected from the cumulative light exposure. This means that the photograph will be underexposed unless the photographer uses a longer exposure than is indicated by the camera lightmeter. When very

long exposures are required, the photographer can compensate for "reciprocity failure" by changing the ASA setting on the camera's film-speed dial. For a four second exposure, set the dial to half the listed ASA rating of the film. Remember to change the ASA film-speed setting back to its initial value as soon as you have taken the photograph (otherwise, the remaining pictures on the film roll will be over-exposed).

Rarely will it be necessary to use exposure times longer than one second. Daylight illumination present in most laboratories and offices is an excellent source of diffuse lighting, and is usually bright enough for exposure times below one second—even when a small aperture is used. It is not advisable to illuminate your specimen or apparatus with direct sunlight shining through a window, as this casts harsh shadows. The film will not be able to accommodate the enormous difference in light inten-

sity between sunlit and shadow areas.

If available daylight is not bright enough for correct exposure with the camera's slowest shutter speed, you can provide additional illumination with a portable desk lamp. Note that the angle from which the object is illuminated by the lamp will affect its appearance. Lighting from the side casts horizontal shadows that accentuate projecting features of the object, while direct head-on illumination eliminates shadows and makes the object appear flat. The angle of illumination is especially important when photographing a glass container or apparatus.

The colour distribution of light from an incandescent desk lamp is quite different from daylight, with a much greater proportion of yellow light. This is of no significance when taking black and white photographs, but must be compensated if one is to avoid a pronounced yellow hue in colour photographs. A blue filter, specially designed to



Close-up photographs can be taken with a rangefinder camera (such as the one shown here) by mounting a close-up lens directly into the threaded recess in front of the main camera lens. Set the camera focusing ring to infinite distance, and carefully position the camera so that its distance from the object to be photographed is equal to the focal length of the close-up lens. Close-up lenses can also be used with a SLR camera, for which no special focusing procedure is necessary.

Note: To avoid blurring caused by hand motion during exposure of this photograph, light was provided by an electronic flashgun. The light pulse from an electronic flashgun lasts less than one-millisecond, which is much shorter than the time period that the shutter is open. Consequently, in flash photography, changing the shutter speed has virtually no effect on exposure. Harsh lighting and shadows associated with direct flash illumination were largely avoided by reflecting the flash from the ceiling of the room. Although the flash beam is "softened" (diffused) by reflection off a ceiling or wall, most of the light is scattered uselessly around the room. The loss of intensity must be compensated by using a wider lens aperture. The f -setting for correct exposure is difficult to judge unless one uses an automatic flashgun equipped with a rotatable head for "bounce flash" photography. Such flashguns utilize a forward-facing light detector to electronically shut-off the flash when sufficient light has been received for correct exposure at a pre-selected f -number setting.

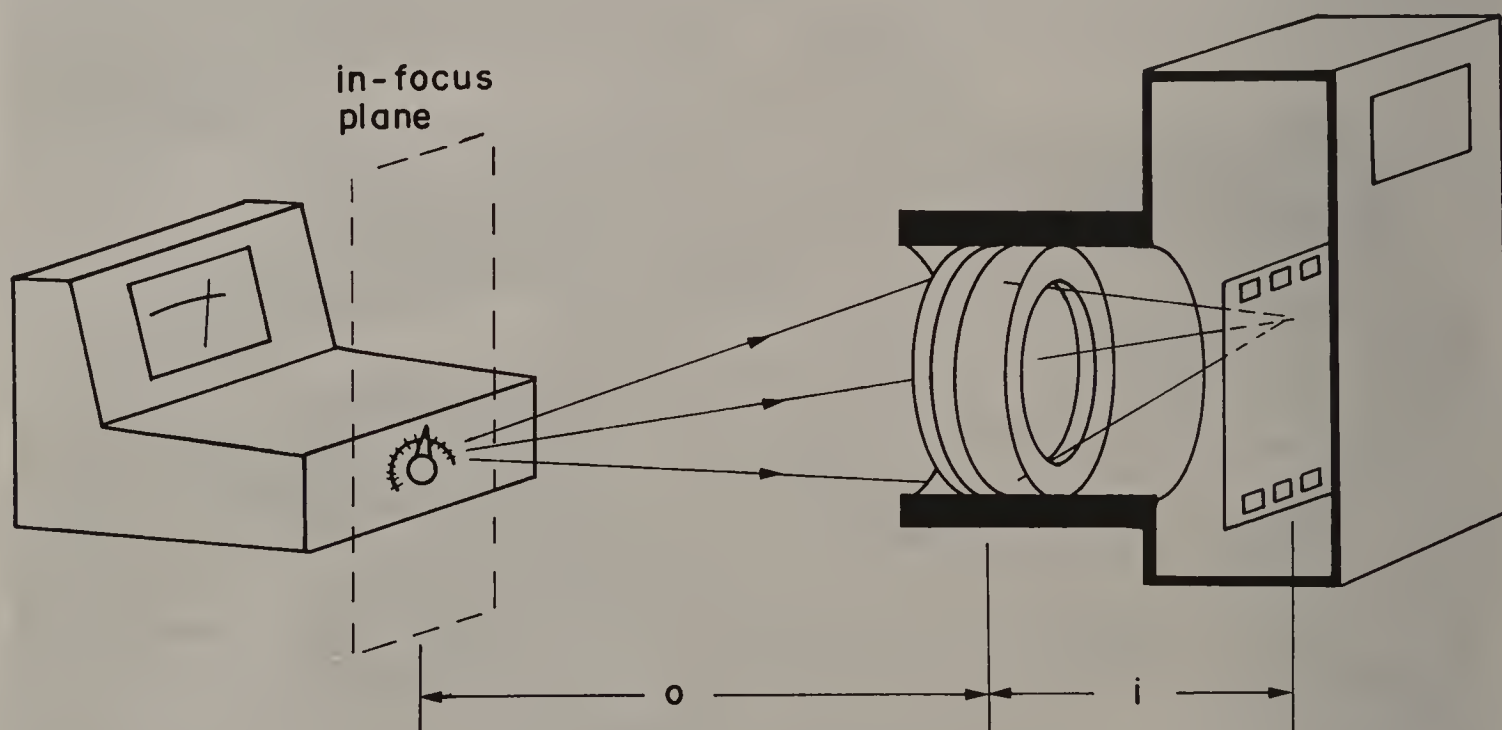
compensate for the colour distribution of incandescent light, can be mounted directly in front of the camera lens. Such filters are made in several sizes, and have an external thread that screws inside the metal rim projecting in front of the camera lens (or attached close-up lens). Alternately, one can use film that is specially colour-balanced for incandescent lighting.

Indoor lighting or a portable lamp can provide sufficient illumination for virtually any photograph one might wish to take of a stationary apparatus. The need would probably never arise for electronic flash which, although extremely useful for photographing people, can cause unpredictable reflections on glass or metal apparatus.

Long exposure times also eliminates the need to use "high-speed" film. Although such films may require only one-tenth or less the light that is needed to expose a medium-speed (ASA 100) film, high-speed film should definitely be avoided when detailed enlargements are desired. All high-speed films have a coarse "grain"—that is, contain relatively large crystals of light-sensitive silver bromide suspended in

a gelatin coating on the flexible plastic base. In areas of a film that are exposed to light, a minute fraction of the silver ions are reduced to atoms of silver metal. Later, when the film is developed, these silver atoms initiate a chain reaction that converts the entire crystal of silver bromide to an insoluble particle of black metallic silver. In crystals which have received little light, on the other hand, there are not enough silver atoms to initiate reaction with the developing solution. Remaining silver bromide is leached out of the gelatin emulsion when the film is soaked in "fixer" solution. This prevents any further photochemical reaction when the film is subsequently exposed to light.

Thus, the photographic image is formed by a series of black specks. The ultimate sharpness and clarity of the image is determined by the size of the silver particles. To obtain a very sharp image, one should use film with very small crystals of silver bromide—that is, fine-grain film. As a consequence of its small crystal size, however, fine-grain film has relatively low light sensitivity (requiring the use of longer exposures or wider apertures).



The image on the film is perfectly sharp when a flat object is located in the plane on which the camera is focused (at distance o from the camera lens). Light leaving each point on this object is focused to a corresponding point on the film image. But what happens when the light strikes the camera lens from another object positioned distance D behind (or ahead of) the in-focus plane? Of course, the lens does not "know" that the incident light rays have come from the distant object; it cannot distinguish a light ray from a distant object and a ray originating from the in-focus plane if they both strike the lens at the same position and angle. Consequently, a ray from the distant object will be focused to a point on the film which corresponds to the point it intersects in the in-focus plane.

Let's consider light rays leaving one point on the distant object. Only a small fraction of the light rays will reach the film; the camera aperture accepts only those rays within a narrow light cone. This cone intercepts a circular area on the in-focus plane. The camera lens projects an image of this circular area onto the film. Then, instead of the light rays being focused to a sharp point, they strike the film within a blurred "circle-of-confusion". When the object is located much further than the distance at which the camera lens is focused (and the rays are nearly parallel), light from each point intersects an area on the in-focus plane which is the same size as the camera aperture. More generally, it can be shown with simple trigonometry that the diameter of the light cone at the in-focus plane equals the diameter of the aperture multiplied by the factor $D/(D+o)$. The corresponding circle-of-confusion at the film image is usually much smaller, since the magnification of the camera (i/o) is generally much smaller than one (except in close-up photography).

High-speed film is very sensitive to light because it contains relatively large crystals of silver bromide. When the negative is enlarged, the specks of metallic silver impart a "grainy" appearance to the photographic print. This would be very pronounced when a small part of the negative, photographed at the minimum focusing distance of the camera, is enlarged to near life-size. Even with little enlargement, prints made from high-speed film usually lack the crispness which characterizes a high-quality image recorded on fine-grain film. While high-speed film can be invaluable to the photographer coping with very low light levels, it should only be used where high light sensitivity is really necessary—and that is usually not the case in scientific photography.

The grain of the film imposes an ultimate limit on how much a photograph can be enlarged, but still show detail. However, the limitations that one first encounters with this type of "close-up" photography are practical considerations of convenience and cost. For one thing, this method is not applicable to 35 mm slide transparencies (which are enlarged only by projection on a screen). For another, most commer-

cial developing laboratories have now installed automated equipment to develop and print photographs, and are becoming increasingly reluctant to provide specialized services—like enlarging one specified area of a negative. Those that do crop and enlarge negatives charge a substantial fee, typically about US\$3 - 4 for each photograph.

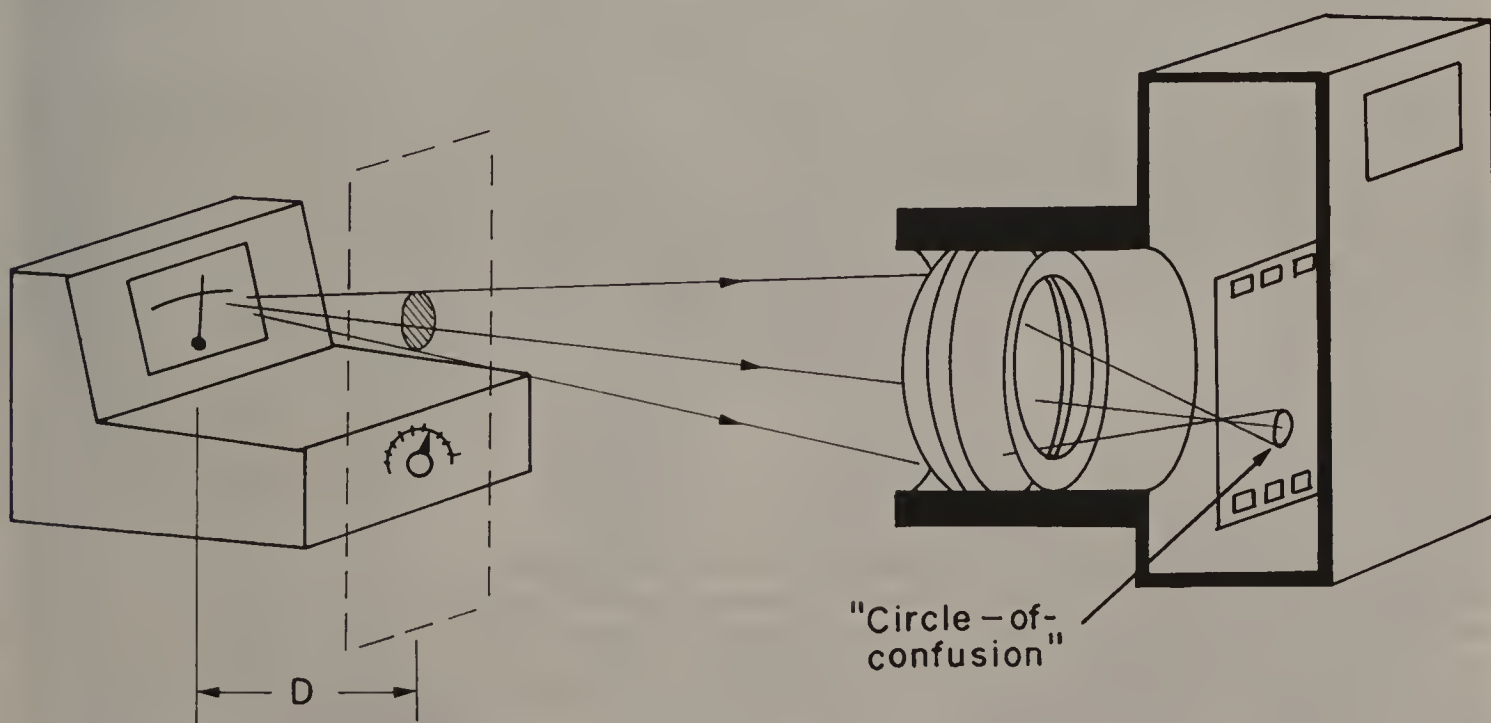
Chemists who may wish to take close-up photographs occasionally will find it cheaper and more convenient to achieve the desired magnification with their camera, rather than by enlarging their negatives. For this, a Single Lens Reflex (SLR) camera offers significant advantages, but any camera can be adapted for close-up photography. The viewfinder of an SLR shows the scene *through the camera lens*. It shows exactly the same image as will impinge on the film when the shutter is opened. With a rangefinder camera, on the other hand, the photographer views the scene through a separate viewfinder located above or to the side of the camera lens. What he views is the scene a few centimetres above or to the side of the area to be focused on the film. The so-called "parallax error" of a rangefinder

At what distance D can an object be located behind (or ahead of) the in-focus plane and remain in reasonable focus? As a criterion for "reasonable focus", we might stipulate that the circle-of-confusion be smaller than about 0.1 mm (on the 35 mm-long film frame). All objects should then appear at least as sharp as the picture on a television screen. To simplify our calculations, we consider only close-up photography, in which the depth-of-field is generally much less than the distance at which the camera is focused (and the factor $D/o + D$ reduces to D/o).

We find that the depth-of-field depends only on the f -number of the camera and its magnification (the relative size of the film image and its corresponding object at the focusing distance). Let's say that we use a camera with a 35 mm film frame, and are photographing an object S mm wide (whose image completely fills the film frame). Then, we can calculate that:

$$D \text{ (Depth-of-field, mm)} = \frac{S^2 f}{10^4}$$

It is immediately apparent that the depth-of-field shrinks very rapidly as the focusing distance is reduced. If we photograph a sample 100 mm across with an f -number of 16 (the smallest aperture available on many cameras), the depth-of-field would extend about 16 mm behind and 16 mm forward of the in-focus plane. In photographing an object about half this size with the same aperture, the depth of field shrinks to within 4 mm of the in-focus plane. Depth-of-field is symmetrical about the in-focus plane only when the focusing distance is small. At larger focusing distances (when our simplifying assumption is no longer valid), the depth-of-field extends further behind—and less distance in front of—the in-focus plane.



camera is normally insignificant, but this is not true in close-up photography, where the device to be photographed might be as small as a few centimetres across. Then, the photographer can no longer rely on a separate viewfinder to position his camera. Nor will a separate viewfinder show if the camera is correctly focused when an additional close-up lens is attached in front of the camera lens.

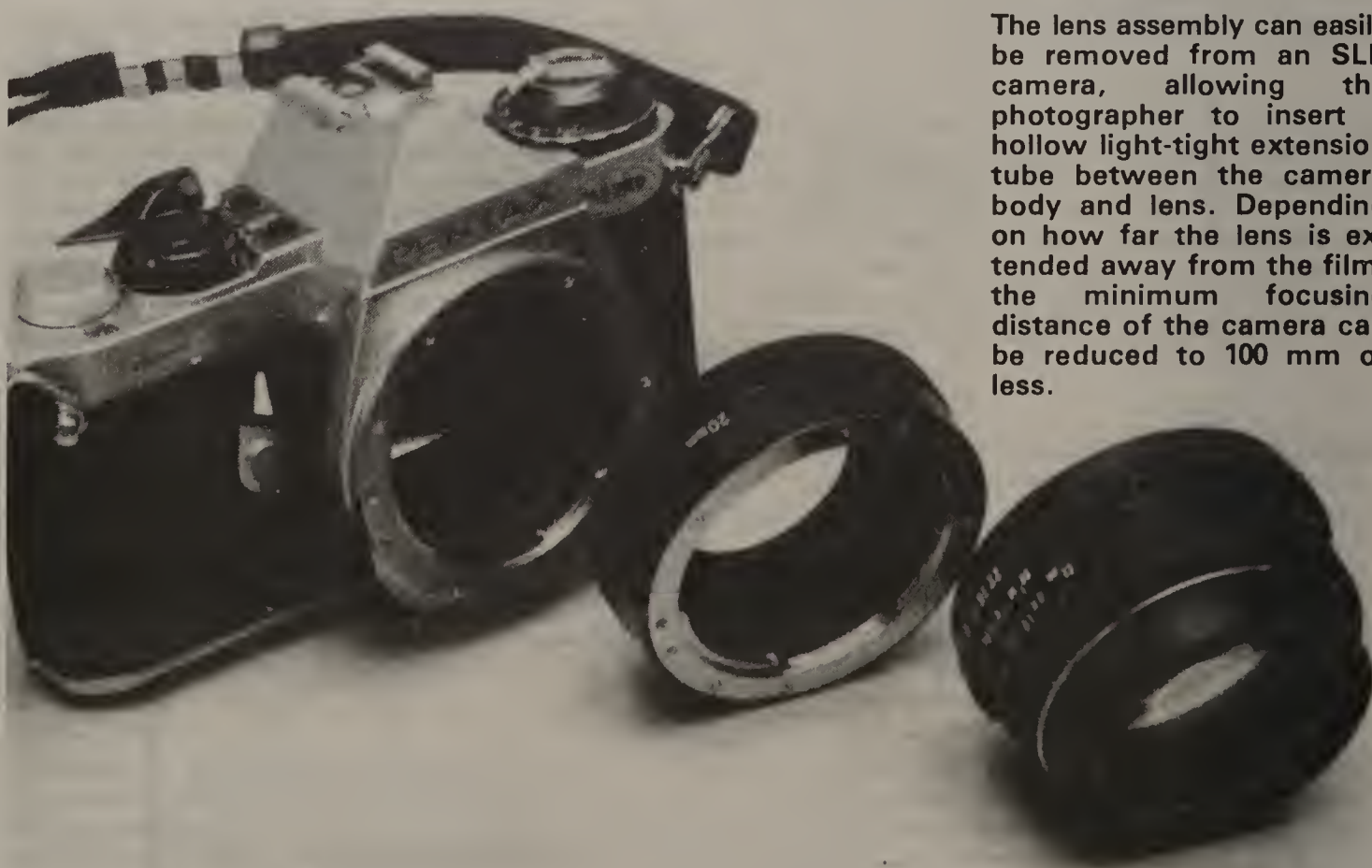
Most 35 mm cameras have a threaded recess on the metal rim projecting beyond the front of the lens. This screw thread accepts a range of matching filters and close-up lenses, which can generally be purchased at very reasonable cost in photographic supply stores. Mounting a close-up lens in front of the camera lens enables it to focus on nearby objects.

When a supplementary close-up lens is attached, an SLR can be focused and operated in exactly the normal way (of course, it will no longer be able to focus on distant objects). However, great care is needed to position and aim a rangefinder camera when a close-up lens is attached. It is impossible for the photographer to judge, by looking through the viewfinder, when the object to be photographed is in focus. Instead, he should position the camera so that the distance from the object to the close-up lens is equal to its focal length. Then, the close-up lens will converge light rays from the object into a parallel beam, as if they had originated at a very distant object. The focusing ring on the camera should be set to infinite distance. Check that the camera is aimed directly at the object to be photographed. A rectangular piece of cardboard, cut to the same length as the focal length of the close-up lens, is a helpful guide

for positioning and aiming the camera.

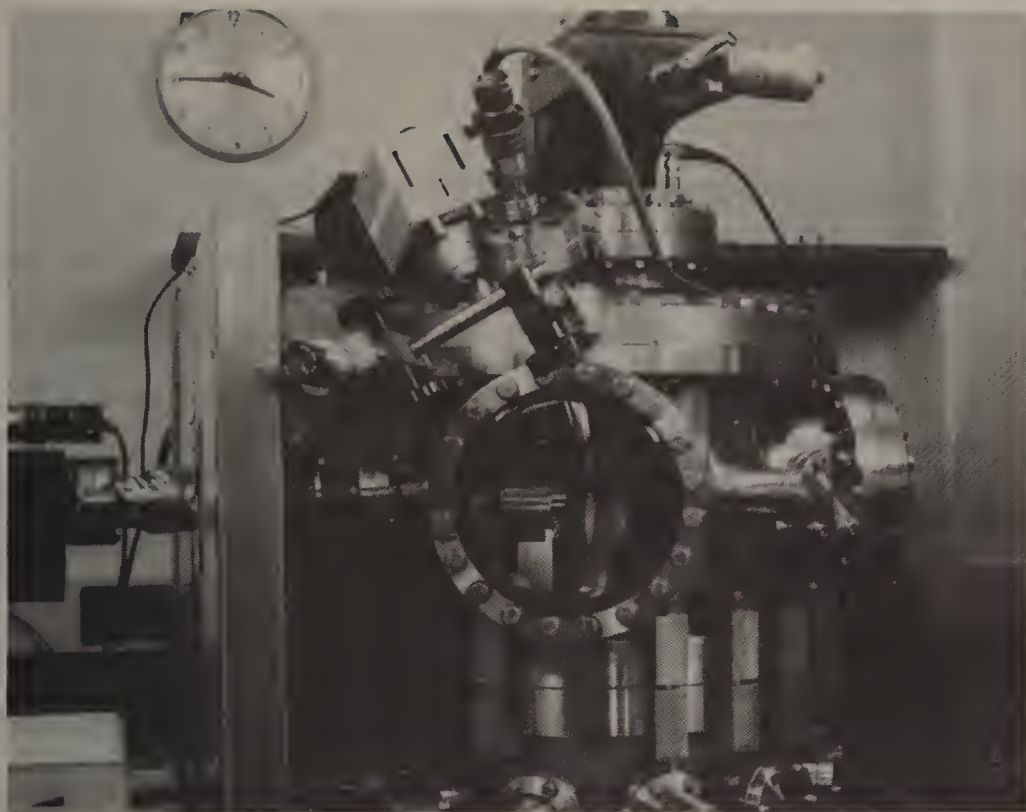
It is not absolutely essential that one purchase a special close-up lens; a magnifying glass or any lens of the appropriate focal length can be used. The lens can be taped over the front of the camera lens. Make sure that the tape does not cover the photocell of the camera lightmeter. The focal length of the lens can readily be measured by forming an image of a distant object on a smooth, flat wall. The image is easy to see in a room with one window. Place the lens against the wall opposite the window, and move it forwards until you see a sharp image of the view out the window. Measure the lens-to-image distance with a ruler. This is the focal length of the lens.

A close-up lens that screws onto the front of the camera is certainly more convenient to use than a magnifying glass, and is a very modest investment for anyone who would like to try close-up photography. The focusing power of such lenses is generally rated in diopters. A close-up lens rated as “+1” diopters has a focal length of one metre. The rating of a lens and its focal length are reciprocal; so a “+4” diopter lens has a focal length of 250 mm. This is a convenient distance from which to photograph small objects (the field of view would be 175 mm wide when using a camera with a standard lens), so a “+4” diopter lens would probably prove the most useful close-up lens. It allows one to form an image on the film about 3 - 4 times larger (with about 9 - 16 times the image area) than would be possible without using a close-up lens. This is the highest magnification for which a simple, single-element close-up lens can provide good image quality.



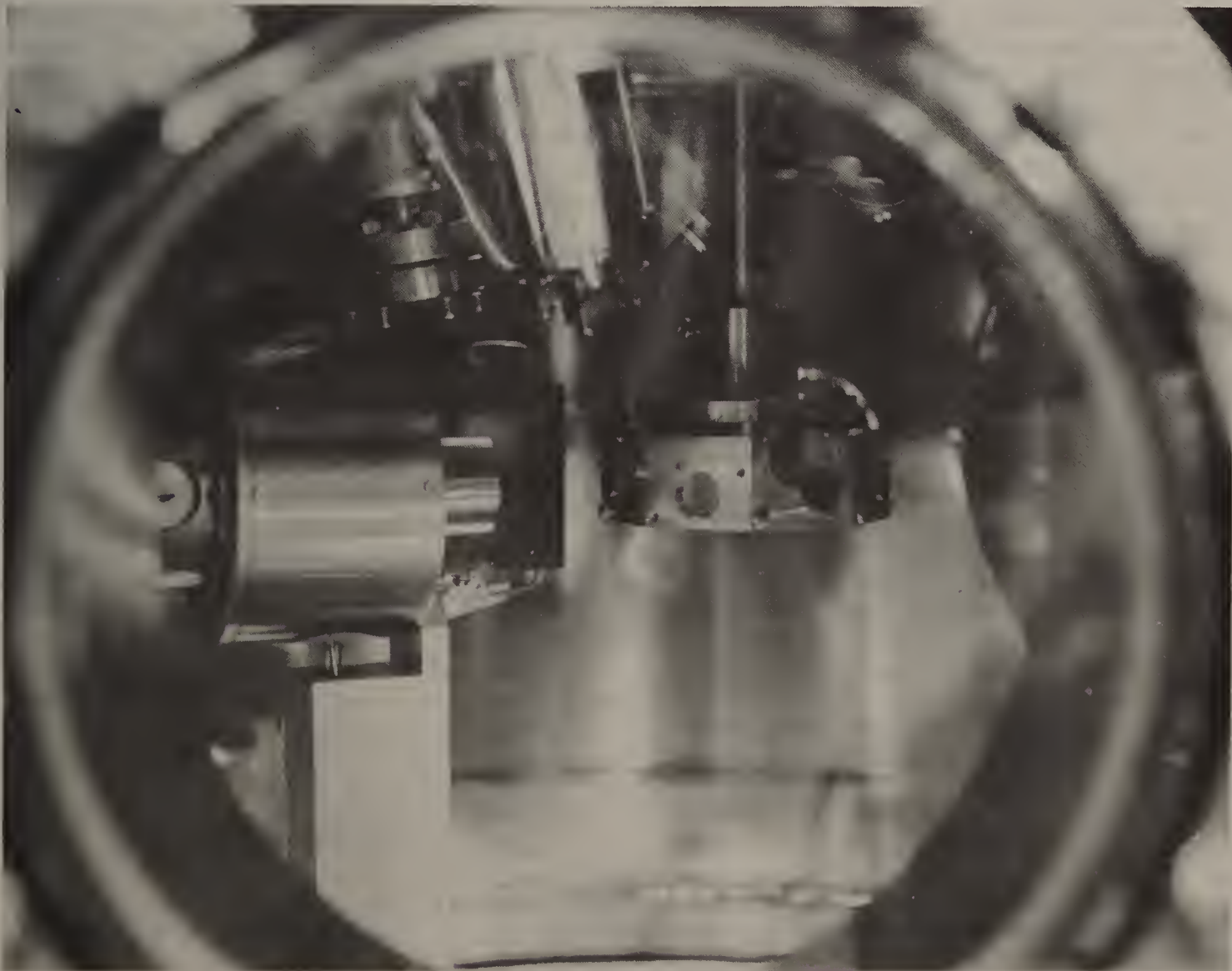
The lens assembly can easily be removed from an SLR camera, allowing the photographer to insert a hollow light-tight extension tube between the camera body and lens. Depending on how far the lens is extended away from the film, the minimum focusing distance of the camera can be reduced to 100 mm or less.

Note: This photograph was taken without a close-up lens or extension tube. A rangefinder camera was used at its minimum focusing distance (0.7 metre), and the negative enlarged to 300 × 375 mm. The print was cut to eliminate extraneous background, and less than one-eighth the picture area was used. With such great enlargement (the picture area reproduced above is 75 times greater than its corresponding area on the negative), some lack of sharpness is evident due to the grain of the film (ASA 120).



The upper photograph, showing a secondary ion mass spectrometer at Imperial College (London), presents a wide view with good depth-of-field. The scene includes a number of components, each of which could be examined by enlarging part of the negative (producing from the central part, for example, a photographic print similar to the one below). A considerable amount of information is potentially available for study. Alternatively, the scene would immediately convey to a lecture audience what the instrument actually looked like and how its various components were arranged. However, it contains too much information to have much visual impact.

In the lower photograph, the viewer's attention is focused through the glass viewing flange into the high vacuum chamber. The viewer can clearly see the target (suspended from a verticle rotatable support, on right) from which secondary ions are ejected by impacting argon ions (travelling from the electrode assembly at the left). Also visible (top) is the entrance port of the secondary mass spectrometer, in which the ejected ions are analysed. These components are located about the same distance from the camera and remain in focus—despite the limited depth-of-field obtained with a relatively large lens aperture ($f4$). However, the flange and mounting bolts (which are of no significance in understanding the operation of the instrument) are too close to be in sharp focus.



3. Close encounters of the third kind

An alternative to using a close-up lens is to insert an extension tube behind the camera lens. This is simply a light-tight spacer which separates the lens assembly and camera body. Extension tubes project the lens assembly forward, allowing the camera lens to bring close objects into focus on the film, making additional lenses unnecessary. Even moderately-priced 35 mm cameras contain a high-quality multi-element lens, whose focusing properties are far superior to a single-element close-up lens. By utilizing only the camera lens for close focusing, we can achieve higher magnification, with less distortion, than is attainable with a simple, low-cost close-up lens.

By inserting extension tubes, one can extend the camera lens as far as required (within practical limits) to achieve the desired magnification. By adding a 50 mm extension tube, for example, one can double the normal lens-to-film distance. Then, an object placed only 100 mm in front of the lens will form an image on the film (located 100 mm *behind* the lens). Consequently, the film image will be the same size as the object being photographed.

Virtually any object large enough to be seen by the unaided eye can be photographed using extension tubes (or flexible bellows). For magnification greater than this, one is no longer dealing with close-up or "macro" photography, but enters the realm of "microphotography" (requiring a microscope or other special equipment).

Although extension tubes overcome the main limitations associated with the use of supplementary close-up lenses, their use is essentially restricted to SLR cameras. In almost all rangefinder cameras, the lens assembly cannot be removed from the camera body. On the other hand, all SLR cameras have interchangeable lenses, allowing the photographer to readily remove the lens from the camera body and insert an extension tube.

By extending the lens-to-film distance, an extension tube increases the effective f -number of the camera. The reduced light intensity striking the film can be compensated by manually increasing the aperture (or decreasing shutter speed) according to an exposure factor calculated for each extension tube (depending on its length). Correct exposure can also be maintained automatically by the camera's lightmeter and electronic control system by using "automatic" extension tubes. These provide a mechanical linkage between the aperture control ring (in the lens assembly) and the sensing/control mechanism in the camera body, so that normal automatic control of the shutter speed or aperture is not interrupted.

Those who plan to pursue scientific photography very seriously might find it worthwhile to purchase a "macro" lens for their camera. Such lenses are specially designed for optimal performance at short focusing distances. By turning the focusing ring, the photographer can vary the lens extension continuously over a wide range, bringing the focus from infinite distance to 100 mm or less. However, a macro lens is an expensive accessory, and may cost nearly as much as the body of an SLR camera.

There is, in fact, virtually no limit to the amount of money which can be spent if one seeks the ultimate in modern photographic technology. One rapidly reaches the "point of diminishing returns", where larger and larger expenditures will be required for each additional gain in flexibility or picture quality. It is best to begin at the beginning, with whatever camera is already available. Then, the scientist can purchase a tripod, close-up lens or extension tubes when he has reached the limit imposed by available equipment, and he wishes to go further.

The birth of nuclear chemistry created opportunities and danger, a pioneer recalls

It is extremely unusual for a chemist to write an autobiography describing the excitement, humour and dangers that he faced on the forefront of a new field of science. But then, John Spinks led an unusual career. His work on the Canadian nuclear energy programme during World War II placed him in a unique position to undertake the first chemical studies with radio-isotope tracers. Immediately after the war, he and his colleagues pioneered many of the techniques that are now standard procedures in chemical laboratories throughout the world.

Dr. Spinks wrote his autobiography upon retiring from the University of Saskatchewan (Canada), where he had spent 45 years and served as Head of the Chemistry Department, Dean of Graduate Studies and University President. Many interesting experiences during his long career are vividly presented in his book "Two blades of grass"*. Here, with permission of Dr. Spinks and the publisher, we reproduce an abridged account of his harrowing introduction to nuclear chemistry, and the fateful events that led him to enter new areas of chemistry that were entirely unexplored and unrecognized.

"... whoever could make two Ears of corn, or two blades of grass to grow upon a spot of ground where only one grew before, would deserve better of mankind . . . than the whole race of politicians put together."

Jonathan Swift, in Gullivers Travels

The time flew by as I became familiar with radioactive techniques: working with invisibly small amounts of horribly radioactive materials, using geiger counters and lead shields, and wearing rubber gloves to avoid contaminating one's hands and rubber overshoes to avoid carrying contamination from one place to another. My closest colleague was Dr. Leslie Cook, and we cooperated in working out a method for separating small amounts of plutonium from slugs of uranium which had been irradiated in one of the American reactors. The slug of uranium was cylindrical, about one inch in diameter and six inches long, and it was extremely radioactive—very "hot" as we used to say. Actually, everything was top secret, so code names and numbers were used for everything—a uranium solution was a "dog" solution, and a highly active uranium solution was a "hot dog" solution. The lead container in which the geiger counter was housed was called a "castle" and the lab., in general, was engaged in "green cheese"

research. The presence of highly radioactive fission products in the irradiated slug complicated problems enormously. At one stage when we had dissolved the slug and had successfully removed the greater part of the uranium, the plutonium seemed to disappear. It was found adsorbed (or stuck) on a few flakes of white material which had dissolved out of the stainless steel from which the container was made. That was bad enough, but practically all the fission product activity had been adsorbed on the same material, and separating them was a nightmare.

One day my wife said to me, "John, your neck is red—I wish you would get rid of this silly habit of scratching your neck." I replied that I hadn't been scratching my neck—probably I had a scratchy collar. "Then change your shirt!" I did so, and in a few days the redness disappeared. Two or three weeks later the same thing happened again and Mary remarked, "It's odd that it's the same shirt." That evening I took the shirt to the lab. and tested it with a

geiger. It was lousy with radioactivity—evidently a spot of highly active material had been splashed on my collar. Quite obviously, splashes might have gone in other places and would have dried off without leaving even a stain.

On testing the floor of the lab, I found it was highly radioactive, and so were the walls and the ceiling, as a result of radioactive dust. Next morning I reported on this. Pontecorvo happened to be present. He immediately made some tests himself and found that my report was correct. His reaction was to phone Dr. Cockcroft and recommend that chemists be barred from entering any other part of the building for fear of carrying contamination with them. At the same time a radiation safety committee was set up on which I sat, together with Dr. Mitchell, a radiologist of great experience from Cambridge. This was one of the first committees to recognize the dangers which might result from chemical operations involving highly radioactive materials. I always credit Mary's acute observations for this very necessary step, and I think she should have got a medal.

At about this time it became necessary to build a pilot plant in which the equipment would be heavily shielded and operated by remote control. It was necessary to get overall approval from Dr. Mackenzie. I was sent with the necessary documents to get his signature.

"Well, John, isn't it nice to see you? Just tell me what has been happening."

After a time I suggested that he must be busy and might like to look through the documents.

"Where do I have to sign?" asked Dr. Mackenzie, and before I could protest, he had put his signature in the appropriate spot.

"But don't you wish to read it?" I asked.

"No," he said. "I presume you have, and if you have made a mistake that is your funeral. You won't make two. Do you want me to scratch out my signature?"

I said, "No, I am quite satisfied."

Dr. Mackenzie said that he had found this method to work very well. If you are going to trust the person, trust them until they indicate that they aren't to be trusted. He said that C. D. Howe worked on this principle, and later I used it to good effect in promotions committees at the university.

In the general survey of contamination, Dr. Goldschmidt's shoes were found to be contaminated and were confiscated. Dr. Goldschmidt demanded compensation. His claim didn't fit in with the usual categories for which compensation could be requested, and eventually the request went to Dr. Paneth, to Dr. Cockcroft, to Dr. Steacie, to Dr. Mackenzie, to C. D. Howe, to MacKenzie King (then, Prime Minister of Canada), and so on back down the line, by which time the document was worth a fortune—or so the story went.

After this episode I was transferred to physics to do odd jobs of a chemical nature. It was good for me in that I learned a good deal about neutrons and the design of ZEEP, the zero energy experimental pile involving heavy water and uranium, and I met many of the physicists involved in the work. This transfer led to my involvement in making a high intensity neutron source, which was required at that time by the medical scientists attached to the project. It was known that when the alpha particles emitted by

polonium were allowed to impinge on metallic beryllium, neutrons were produced. Only small amounts of polonium had been used up to that time, a few tens of millicuries at most, because of its dangerous nature. The Americans had offered to supply about a thousand times as much, ten curies in fact, in the form of a deposit on a thin piece of platinum foil.

I was given the task of making this neutron source, and I had the idea of making a sandwich of the piece of polonium-coated platinum between two slices of beryllium metal. The whole would be placed in a brass cylinder closed by a screw top, which could be soldered in as an extra precaution. The whole operation was to be carried out in a box fitted with a glass top and with rubber gloves projecting in from each side. Such boxes are commonplace nowadays, but they were quite unheard-of in those days. After doing a dummy run many times until I thought I could do it perfectly, I put the real thing into the box, closed the lid, and started to work. At first everything went well, but at the last minute the sandwich refused to slide neatly into the brass cylinder. I was horrified, since such a possibility had not even entered our heads. I started to sweat, and I stepped back for a couple of seconds to think what to do next. I disengaged the parts and tried again. This time everything worked to perfection, and I breathed a sigh of relief and finished the operation.

Actually, one thing we didn't know at the time was how dangerous the neutrons were. We found later that they were horribly dangerous, and for a long time after the war I would wake up in the night, thinking that the finger and thumb which had held the neutron source were warmer than the rest of the hand. I have decided since that the problem was psychological, but at the time it was quite a worry. I was fortunate to come out all in one piece and with firsthand ground-floor experience of two important principles—operations research and atomic energy. I had also seen at first hand how horrible man can be to man, and yet how self-sacrificing men and women can be.

Early in August of 1945 the "bomb" was dropped and the war with Japan was over. I was shocked that the atom bomb had been used against a city, and I deeply regretted that it had been used at all. The Canadians had, of course, been working on the development of a heavy-water reactor and not on the bomb, but it was generally known that something of this kind was in the wind, and that at one time it had been felt to be terribly urgent that the Allies get such a bomb before the enemy did so. Now the shadow of the mushroom cloud was to grow bigger and bigger, to influence for all time public feeling toward atomic energy.

A day or so later, a small item in the local paper listed the names of a number of Canadian scientists who had been working with the Canadian atomic energy project, my name among them. I was immediately deluged with questions by my colleagues and with requests to speak to service clubs and church groups. I did my best to oblige, keeping in mind that all the wartime work on atomic energy was still top-secret. Fortunately the Americans soon released a good deal of information, so that it became possible to say quite a bit about atomic energy without revealing any secrets.

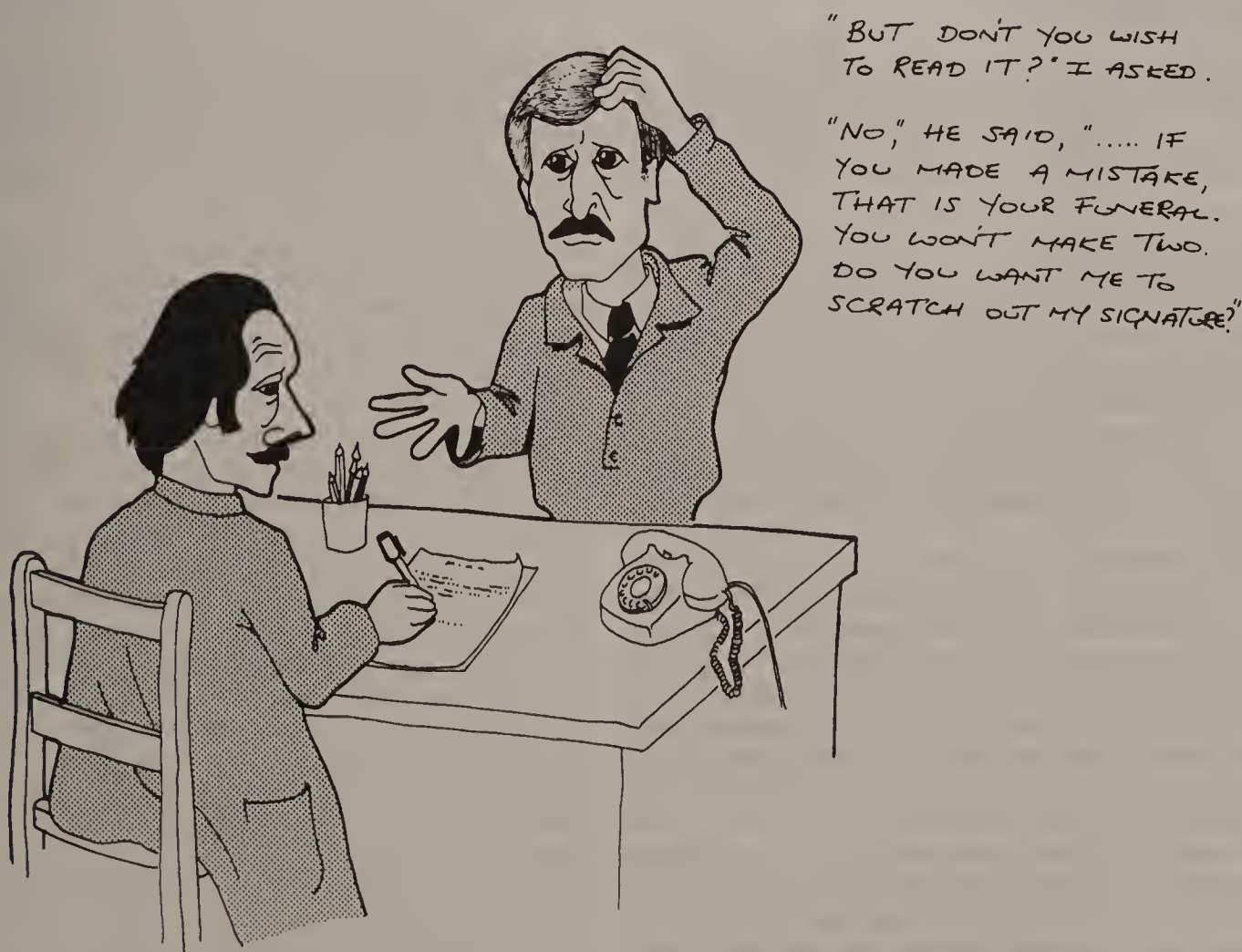
With the partial lifting of the secrecy veil I started to make preparations to use radioactive isotopes in non-secret work. The National Research Council was most cooperative in loaning me the basic equipment for measuring radioactive isotopes that I had used in Montreal—a scaler, one or two geiger counters, and even some lead bricks. Dr. Steacie took special pains to loan us a 250 mg. radium-beryllium neutron source which could be used to make small amounts of radioactive isotopes. As an example, radioactive phosphorus could be produced in small amounts by irradiating carbon disulfide with the neutrons from the source.

Shortly after I had assembled the equipment, Dr. John Mitchell, head of the soil science department, dropped over to my lab. for a chat, and I proudly showed him my new toys and asked whether he would be interested in doing some cooperative work using isotopes. When he asked me how, I had to confess that I didn't have much of an idea, and I asked him to give me a rough idea of what sorts of research he was doing. After outlining the soils mapping for which his group was famous, he said, "Of course, we also do some work on phosphate fertilizers, finding out how the application of fertilizer improves the yield." I immediately had an idea, and I asked whether there would be any interest in knowing how much of the fertilizer was being used by the plant. He said that there certainly would, since at that time there was no way of telling where the phosphorus in the plant had come from, whether from the soil or

the fertilizer. I suggested that we could make radioactive fertilizer and measure its intake by the plant, using radioactive methods. If we then measured the total phosphorus uptake chemically, the difference between this and the fertilizer phosphorus uptake would be the amount of phosphorus coming from the soil. This procedure is the basis of the so-called tracer method, in which the material is labelled with radioactivity and can then be traced wherever it goes.

Dr. Mitchell lent me a student, Stan Barber, who did some greenhouse experiments during the winter with three or four wheat plants growing in a pot to which small amounts of radioactive phosphorus, P-32, in the form of phosphate (made by using the neutron source) had been added. When we tried to publish an account of the experiments, the reviewer said that the experiments were quite accurate but that they didn't mean anything to anyone except Dr. Spinks. I developed an explanation using red and green balls mixed in a bag labelled "fertilizer" and I sent it with a rather sarcastic letter to the editor, who had the article reviewed by other reviewers. Fortunately they agreed with me, and the article was published—the first in the world along these lines.

We then wished to do some field experiments, but for this purpose we needed much larger amounts of P-32, which were not then available in Canada. I wrote to various people in the United States, but they all replied that their particular atomic machine was under the McMahon Act, and radioactive materials made in it could not be exported. Eventually



Professor Urey suggested I write Lawrence in California, who suggested that I try Evans at the Institute for Terrestrial Magnetism in Washington, D.C. For some strange reason his cyclotron had been overlooked in the McMahon Act, so for the next year he regularly sent me one mc. of P-32 each month in a small wooden box labelled "chalk sticks". It was quite harmless from the point of view of radiation, but it would have been somewhat difficult to explain to the customs authorities, had they ever asked to examine the sticks of "chalk". With this P-32 we did the first field experiments in the world at Floral, just outside Saskatoon. I have always felt deeply indebted to Dr. Evans, who did not know me personally but who went out of his way to help a fellow scientist.

In subsequent experiments we tried the effects of different types of soil, weather, crop, method of application, and so forth, and developed improved technical methods of measurement. These all seem terribly simple nowadays, but in those days no one had thought about them, and each one represented quite a breakthrough. Once again I was lucky enough to be in on a new series of experiments, and I got a great stimulus from taking part in it.

In no time at all we were using isotopes to measure phosphorus and calcium in eggs; the movement of wireworms; the dispersion of grasshoppers, mosquitoes, and blackflies; the effect of dicoumarin as an anticoagulant; the effects of vitamins K₁ and K₃; and so forth. Each time I worked with an expert in the field, who contributed his particular knowhow while I contributed some radioactive knowhow. This approach seemed to work well. Quite apart from doing a particular piece of research, I gradually acquired a better-than-average knowledge of the scientific work in progress on the campus and of the corresponding scientists.

A good deal of the work we did had practical applications, and doing this type of research was good for me. As an example, the fertilizer experiments led to literally thousands of pieces of work by research workers all over the world, and they led in turn to a better understanding of how fertilizers work, of the availability of soil nutrients, and of how to make improvements in fertilizer practice. Instead of effects being guessed at, they could now be measured accurately and the proper advice could be given to farmers on fertilizer practice for their particular types of soil. The value of such advice can only be measured in millions of dollars, and it will become particularly valuable as food supply becomes the determining parameter in relation to population limits.

After working on a good many different applications of isotopes, I became convinced of the long-term value of this work, and I urged that a laboratory be set up to exploit this new tool. Unfortunately, a number of people in powerful positions felt that isotopes were just like a new piece of equipment, and they failed to realize that radioactive isotopes produced many different effects, and that in fact they open up a whole new world.

I did get minor consolation from unexpected references to the Saskatoon work. One was in Geneva, in 1955, when Mary and I attended a public lecture on radioactive tracers given by Nobel Prize winner Hevesy. After introducing the subject, he said

that he would now point out the practical application of isotopes by referring to some work done in far-off Saskatchewan by a young man named Spinks. He then showed two slides taken from my first P-32 paper on fertilizer uptake. It was quite one of the most thrilling moments in my life, and afterwards Mary and I introduced ourselves to Professor Hevesy. I had had no idea that he knew of my work.

On another occasion, nearly twenty years later, I visited an agricultural research station just outside New Delhi in company with a number of university vice-chancellors. In the entrance to the building were several large panels illustrating various types of isotope work. The first panel was illustrated by the same graph that Hevesy had shown, and I innocently asked our guide who had done the work.

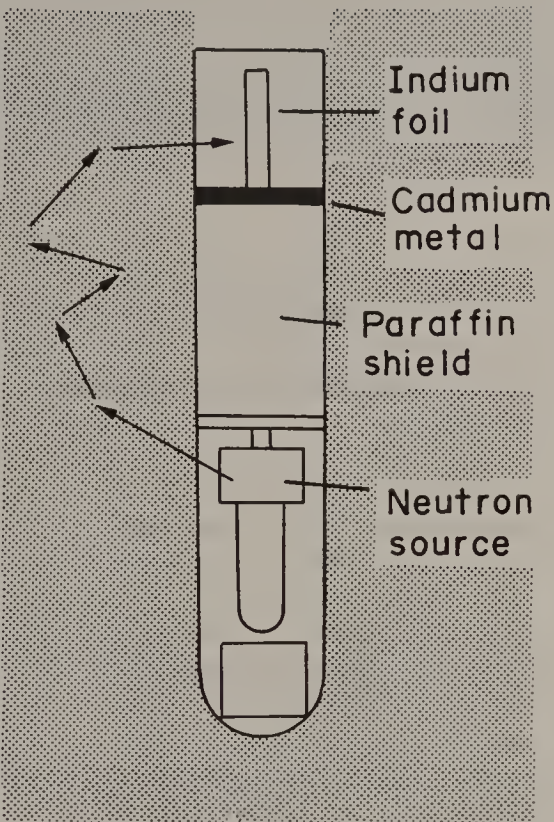
"A chap named Spinks, lives way off in Canada."

After a few minutes the guide came up to me and said, "Say, your name is Spinks too, isn't it?" I agreed that it was. A few minutes later we came to a panel on a neutron moisture meter for use in irrigation work—again from one of my papers. Again I enquired about the author, and the guide said, "It's odd that you should ask—it's also by a chap named Spinks—might possibly be the same fellow." Then he suddenly blushed and said, 'Good Lord, it's you!'

The development of the neutron moisture meter came about in an interesting fashion. Professor Torchinsky was at that time interested in soil mechanics, and he needed to be able to measure the per-cent moisture in the soil. So he came to my office and asked if one could use isotopes for this purpose. I said that one could probably use tritium, but that it would be very awkward—much more bother than the usual method of weighing and drying. However, Professor Torchinsky had no sooner left my office than I remembered that the famous Italian physicist Fermi had written a paper in 1934 in which he had found that the ability of neutrons to induce radioactivity in metals was much enhanced if the whole system was surrounded by hydrogenous material. Quite obviously, since water contained hydrogen, the method should work for soil containing water. A few experiments using wet sand in a beaker and a silver quarter, with the neutron source as measuring instrument, showed that the idea was sound. Later the quarter was replaced by a slow-neutron counter filled with boron trifluoride. Actually, what was happening was that fast neutrons, emitted by the neutron source, were being slowed down by collision with the hydrogen in the water; the more hydrogen there was, the more slow neutrons were produced. We did think of patenting the idea, but we were eventually persuaded to publish the data instead, since ideas as such are not patentable, but only devices making use of the idea. In any case, it was suggested that not many of these devices would be produced. Actually the device is now widely used in irrigation work. A one-inch diameter pipe is pushed into the soil, the instrument is lowered into the hole, and the percentage moisture read on a dial—a very simple device which does not require removal of the soil. Our main satisfaction was again to get the first publication in the world on this particular topic. Which brings me back to green cheese research!

In 1978, when the eleventh International Congress for Soil Science met in Edmonton with fifteen hun-

Components of the first soil moisture meter were assembled in a test tube by Dr. Spinks in 1951. The radium - beryllium source emitted high-energy (1 MeV) "fast" neutrons, which dissipated their kinetic energy during repeated collisions with light atoms. Because of the small nuclear mass of hydrogen, this element—and compounds containing hydrogen—were particularly effective in slowing the neutrons. Slow neutrons scattered from water molecules in the surrounding soil were absorbed by an Indium foil, forming the short-lived radioactive isotope In^{116} .



Within about an hour after the probe was inserted into the soil, the amount of In^{116} approached a constant level (at which In^{116} underwent radioactive decay at nearly the same rate as it was produced). Radioactivity induced in the iridium foil, measured with a Geiger counter, was proportional to the amount of hydrogen-containing compounds in the material surrounding the moisture probe. Water is the major hydrogen-containing constituent in soil, although a cylinder of paraffin wax was used to calibrate the probe.



WAX CALIBRATING CYLINDER



An improved design of the moisture probe (shown in the photograph above) was introduced in the same year for field trials. By utilizing an indium foil with a large area, it allowed use of a much smaller Ra - Be source and shorter irradiation times (*photograph courtesy of Dr. Spinks*).

dred people from all over the world in attendance, I was asked to give the lead-off paper in a seminar on isotopes in agriculture. I gave an historical overview of the early beginnings of the research in Saskatchewan under the title, "First Steps in Green Cheese Research." The paper attracted a good deal of favorable attention. At the conclusion of the symposium I was given an honorary membership certificate in the Canadian Society of Soil Scientists, much to my surprise and pleasure.

Eventually one gets tired of green cheese, and so I gradually switched my research from tracer research to radiation research—the action of radiation on chemical systems. It turned out to be an exciting and rewarding field of research. Shortly after World War II, the Chalk River reactor started to produce isotopes in large quantities, and these became available for use in scientific research. In particular, the radioactive cobalt, Co-60, provided an ideal source for gamma rays, which could be used for therapeutic purposes and in radiation chemistry. As is well known, Dr. Harold Johns of the University of Saskatchewan developed a cobalt radiation therapy unit for use in cancer therapy. At the same time he

acquired other sources of high-energy radiation including a betatron. This seemed to offer an ideal opportunity for me to extend my photochemistry, which involved the action of light on chemical systems, to somewhat higher-energy radiation. So I gradually switched my research interest to radiation chemistry, and again I hit pay dirt. Practically everything one thought of led to a new type of experiment and to new results. And the students found this new area of research interesting because one could almost guarantee that results would be forthcoming.

We had an enormous advantage, of course, in that we could talk to members of the physics department, and get a good understanding of the physical effect of radiation on the system being studied. Very few chemists were in this fortunate position. So we studied the effect of different types of radiation on gaseous, liquid, and solid systems, studied reactions at both low and high temperatures, and eventually started to study the fundamental particles produced when ionizing radiations interact with matter. It is thought that free radicals are produced; for example, when water, H_2O , is irradiated, H and OH radicals are produced. These radicals can be studied using

electron-spin equipment. Concurrently with the research on radiation chemistry, I gave lectures in the field and eventually wrote a book, *Introduction to Radiation Chemistry*, in collaboration with a colleague, Dr. R. J. Woods. Our rather wide-ranging research had put us in an ideal position to write such a book. At the time there were highly specialized books on the action of radiation on gases, on water, or on solids, but no one had thought of taking a general approach, so we were quite lucky again.

In recent years there has been an increasing interest in studying the properties of free radicals in greater and greater detail; for example, the lifetime of a free radical is a matter of considerable interest. Studies of the lifetime can be made by using intermittent or pulsed radiation, in which the material under study is irradiated with short bursts of radiation, rather than continuously. The observed rate of reaction then depends on the relation between the rate of pulsing of the radiation and the mean lifetime of the free radical in question. We had access to a powerful beam of gamma rays in the University Hospital, and we were able to pulse this beam by interposing a slotted lead cylinder, about one foot thick, between the source of radiation and the material being irradiated, and then rotating the cylinder. We were able to rotate the cylinder about one thousand times a second and to measure radical lifetimes of one thousandth of a second—some of the first measurements of this kind.

Later we were able to extend the measurements to one-millionth of a second, using the linear accelerator on campus which produced a pulsed beam of electrons, pulsed at one million times a second. Still more recently, the method has been extended to a few nanoseconds. Free radicals have now been studied in great detail by a variety of techniques, so that chemists have a considerable degree of confidence that free radicals really do exist. Without getting into the problem of what one means by exist, let us say that the free radicals now have the same degree of reality for the chemist as, say, the chair in which he sits.

Possible industrial uses of radiation are now being actively explored in a number of countries. In 1950 Dr. Armstrong worked with me on the synthesis of ethyl bromide by irradiating a mixture of ethylene and hydrogen bromide with gamma rays from Co-60.



Immediately after the Second World War, nuclear researchers were not permitted to freely discuss their work with colleagues or with the general public. This 1945 photograph shows Dr. Spinks placing a radioactive sample under a home-made Geiger counter tube inside a lead-lined enclosure (photograph courtesy of Dr. Spinks).

The reaction takes place rapidly at room temperature, producing ethyl bromide which is 99.8% pure.



The process has now been used by Dow Chemical to produce ethyl bromide, a common organic chemical, at the rate of five thousand tons a year—not a vast output, but an indication that the process can be done commercially.

* *Two blades of grass*, by Dr. John Spinks, 1981, paperback C\$9.95 (from Western Producer Prairie Books, P.O. Box 2500, Saskatoon, Saskatchewan S7K 2C4, Canada).

New policy encourages wider participation in drafting new nomenclature recommendations

The mechanism by which IUPAC Commissions issue recommendations for nomenclature and symbols is a two-stage process. A Commission initially proposes new nomenclature recommendations by submitting a document for publication in *provisional* form. When approved by the respective IUPAC Division (say, the Organic Chemistry Division) and by IDCNS*, the *provisional* report is published in the IUPAC journal *Pure & Applied Chemistry*. This initial publication allows chemists throughout the world to comment on the recommendations. After a minimum period of eight months has elapsed, all comments are considered by the original Commission, and the recommendations are amended as necessary before republication in the IUPAC journal in "final" or *definitive* form.

With this procedure, each set of recommendations is published twice, sometimes with negligible changes. As well as being confusing, double-publication has become unacceptable because of increasingly stringent restrictions on space in *Pure & Applied Chemistry*. Furthermore, there has been growing doubt whether it is the most effective method to bring about general awareness of new recommendations and to elicit comments from the chemical community. It is also recognized that the categories "provisional" and definitive" are really inappropriate, since the practice of chemistry is constantly changing, and all recommendations are inevitably subject to further revision.

The Executive Committee has therefore agreed to try an alternative procedure which, it is hoped, will provide greater opportunities for chemists outside the IUPAC framework to respond to proposed recommendations before they are formally published. This new procedure is to be introduced this year.

The new policy requires each Commission to consult outside experts at the earliest possible stage in the preparation of all recommendations on nomenclature and symbols. In the past, many Commissions have consulted experts in the field even *before* submitting their provisional documents for publication. The IUPAC Executive Committee would like these efforts to be intensified and expanded so that useful comments and suggestions can

be obtained from a broad spectrum of the chemical community—without provisional publication in the IUPAC journal.

After their draft recommendations have been revised, the Commission (in conjunction with IDCNS) will compile a list of additional experts (and their addresses), and submit these to the IUPAC Secretariat for dissemination of the recommendations. The IUPAC Secretariat will send photocopies of the manuscript to these experts and to about 10 key international editorial groups (as well as editors of any specialist research journals suggested by the Commission).

To draw additional attention to impending publication of the recommendations, a brief synopsis (prepared by the Commission and submitted with the document) will be published in the IUPAC news magazine *Chemistry International***. Copies will also be provided to editors of national chemistry journals, who will be asked to publish the synopses and invite their readers to review the recommendations and submit comments. Photocopies of the full document will be available on request from the IUPAC Secretariat.

The Commission will then consider all comments and suggestions that are received, modify their recommendations accordingly, and finally submit an amended report for publication in *Pure & Applied Chemistry*. This report will not be termed "final/definitive", but will simply be characterized by the year of adoption by IUPAC.

* IDCNS (the Interdivisional Committee on Nomenclature and Symbols) ensures that appropriate IUPAC bodies and international standardizing organizations are consulted, and a consensus agreed, before approving IUPAC documents for publication.

** *Chemistry International* presently publishes short (200 word) summaries of nomenclature reports in press. The new policy requires that the summaries are to be published *before* the reports are amended for publication.

The *Chemistry International* Experiment

In 1977, the IUPAC Council decided to initiate a new chemistry magazine. It was intended to be a popular publication with a wide readership among chemists throughout the world, and to serve as an information medium to keep the average chemist aware of what IUPAC was doing. That magazine, later to be entitled *Chemistry International*, was to be subsidized for a trial period, after which it was hoped the magazine would become financially self-supporting.

The formation of an international chemistry magazine represented a dramatic departure from any previous IUPAC undertaking. Indeed, no similar publication had ever been attempted before. There are, of course, many national chemistry magazines published by chemical societies. These restrict their scope to chemical developments within that country or region, and have little coverage of events outside a defined geographical area. There are also hundreds of specialized chemistry journals which focus upon a particular aspect of chemistry; chromatography, mass spectrometry, organic synthesis or electrochemistry, to name a few.

Existing chemistry journals and magazines are aimed at a clear target audience defined by national boundaries, field of specialization or language. If successful, they can achieve intensive readership within their respective limited "sphere-of-influence".

By contrast, the proposed IUPAC magazine could not—by its very nature—restrict its scope within any national boundaries or field of specialization. While it aimed at a very broad potential market (perhaps a million chemists worldwide), one could only expect an international chemistry magazine to reach a small fraction of the chemists in any one country. It could not compete with national chemistry magazines, which can provide in-depth coverage of developments and events within that country. National magazines can also tailor their coverage of international events to emphasize those aspects relating to the special circumstances existing in that country (educational requirements, environmental conditions, natural resources and indigenous industry). An international chemistry magazine would have none of these advantages. It must offer its readers something that they cannot readily find in national chemistry magazines or specialized journals.

It was clear from the outset that the IUPAC magazine needed to develop an international outlook, and discuss chemical problems of international scope. Several areas for coverage were immediately apparent: global energy supplies, air and water pollution, depletion of the ozone layer and other chemical processes in the upper atmosphere, and development of new pesticides and agricultural chemicals. IUPAC's CHEMRAWN concept (*Chemical Research Applied to World Needs*) encompassed a range of subject areas on which *Chemistry International* might focus.

Because it was to be published every two months and mailed overseas, *Chemistry International* could not provide coverage of the latest developments near-

ly as effectively as could weekly, biweekly or monthly national chemistry magazines. The considerable time lag for publication was not, however, as limiting as might have been imagined, since chemists are generally not aware of (or do not understand) important developments outside their own area of specialization. It thus seemed reasonable to discuss interdisciplinary developments involving chemistry, chemical engineering and biochemistry. These had to be discussed in the broadest possible context, in a way that all chemists could understand. Each article would project a long-term overview of the subject and evaluate the implications of past and future developments.

Even within the broadly-defined niche in which *Chemistry International* might establish eminence, there remained enormous latitude in choice of material, method of presentation and style. The content of *Chemistry International* evolved naturally, according to the judgement and abilities of the Editor.

Chemistry International was provided to all 1000-or-so members of IUPAC Commissions, Committees and Working Parties, replacing the *IUPAC Information Bulletin*. An additional 500 copies of each issue were provided to national science academies, chemical societies and other chemistry organizations in IUPAC's 44 members countries, including 200 chemical companies which belong to IUPAC'S Company Associate Scheme. However, the main criterion of success was not how well *Chemistry International* was received within IUPAC's Commissions and associated organizations, but how many people *outside* the IUPAC framework were willing to subscribe.

The content of a magazine very much reflects its readership group, just as a particular group of readers chooses a magazine because of its content. With a new magazine, for which neither the content nor a readership group are yet established, this "chicken-and-egg" relationship poses a difficult dilemma. The Editor must aim to achieve a content and style that will appeal to future subscribers, although he doesn't know *who* his subscribers will be and *what* they will want to read. He can only guess who a typical reader might be, and what such a person might want to read. This was especially difficult for *Chemistry International*, for which a "typical reader" might have any conceivable nationality, might be an organic or physical chemist, and might work for a large multinational chemical company or for a rural technical college.

Chemistry International now has about 1000 subscribers (in addition to its distribution within IUPAC). This is certainly insufficient for the magazine to be financially self-supporting, but whether this limited achievement is judged as success or failure depends on one's point of view. Certainly, many individuals within IUPAC were initially critical of its content, probably because it was so different from anything that IUPAC had ever published before. It now appears to be well-received and liked by most IUPAC participants. One unsolicited letter

to the Editor by a IUPAC Commission member (recently retired) stated, "I had no enthusiasm for the transformation of the *IUPAC Information Bulletin* into *Chemistry International* . . . —and I still think there is a place for the *Information Bulletin* in its old style. . . . However, I now write to say that you are gradually winning me over to admiration for *Chemistry International* as a journal."

Another Commission member recently wrote, "For me, it is always a pleasure reading the magazine *Chemistry International*. The way in which the articles are written should be called ideal, as everything is so well understandable and still of high scientific value."

One Commission member wrote to Secretary General Ourisson to express his regret that foreign currency regulations prevented him from purchasing his own subscription. He wrote, "I very much appreciate *Chemistry International* as a remarkable improvement of IUPAC contacts with the whole community of chemists. I am often exploiting quite a number of suggestions from it when preparing our (chemical society) bulletin."

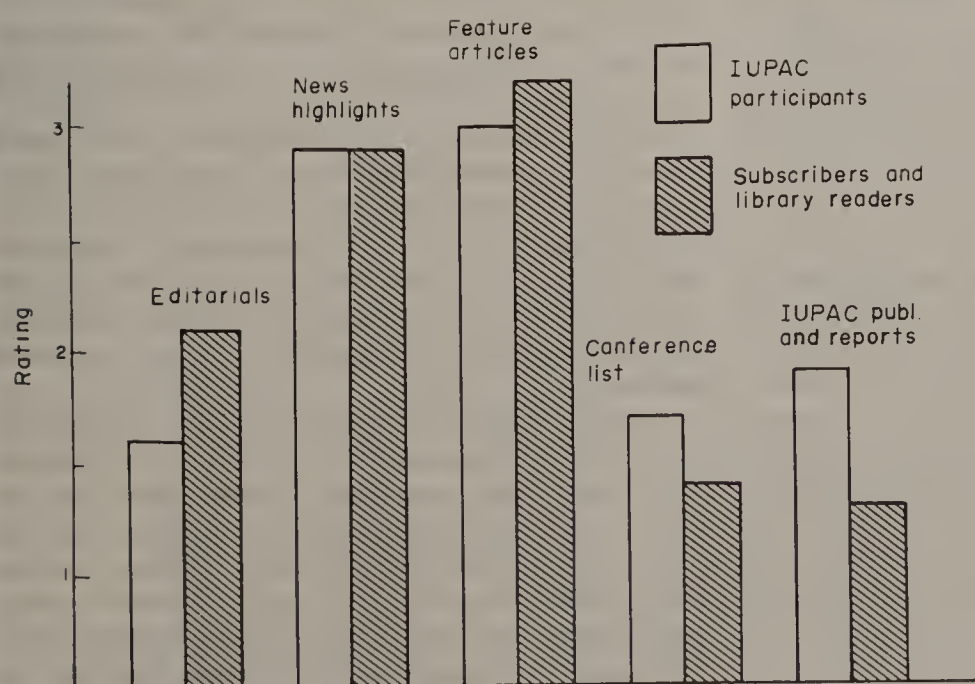
However, one letter sent by a Commission member during the last year was very disparaging. It stated that, "At a time when library budgets are being cut, and subscriptions to significant journals are being cancelled, an additional new title has little chance of being taken unless it provides additional information not readily available elsewhere. I do not find such information in *Chemistry International*. Almost all articles in this year's issues can be matched by similar items elsewhere. This is not to say there is anything fundamentally wrong with them, just that they duplicate other secondary sources of information."

He continued, "You asked me (in a questionnaire) which features I have enjoyed in recent issues, and I would pick out the report on IUPAC conference sponsorship (in *Chemistry International*, No. 1, 1981, p. 13) and "Presenting your research results" (in No. 3, 1981). The "Recent Reports" entry is a useful check to see if I missed the original in *Pure & Applied Chemistry*, but otherwise I find *Chemistry*

International rather a waste of time. . . . Reading Professor Zollinger's message (in No. 3, 1981, p.2) on the serious financial problems of IUPAC, I must question whether the union can afford to publish a throw-away magazine of this type." This letter is unique. No other correspondent expressed such a negative view towards *Chemistry International*.

How well does the present content of *Chemistry International* serve the needs of its readers? The readership of *Chemistry International* is comprised of several distinct groups. One would expect IUPAC Commission members to have a different outlook than subscribers or library readers, and in fact, this is what emerges by analysing the results of a readership survey. Among 48 Commission members who returned a questionnaire (loosely inserted in *Chemistry International*, No. 2, 1981), nearly two-thirds indicated that more coverage of IUPAC activities would be their 1st or 2nd preference for additional content. Subscribers and library readers, on the other hand, gave IUPAC activities much lower priority. When asked to rate four different types of articles (coverage of technical developments, general interest articles, "How to" articles and coverage of IUPAC activities) responses from 46 individual members and library readers indicated a clear preference for discussion of technical developments, and placed least emphasis on coverage of IUPAC activities. In fact, all three groups—IUPAC participants, individual subscribers and library readers—indicated unequivocally that they found the news highlights and feature articles to be the most interesting or useful features. Their interest in editorials, the conference list and information about IUPAC publications and reports were clearly of secondary importance.

Surprisingly, survey respondents did not express a particularly strong preference for "How to" articles, although these have elicited an extraordinary demand for reprints and requests for permission to translate and reproduce these articles. The first, "Presenting your research results", provided practical guidance for conference speakers to improve their lectures, slide transparencies and posters. It seemed to fill a



Both main *Chemistry International* reader groups—IUPAC participants and individual subscribers/library readers—rated News Highlights and Feature Articles as having substantially greater interest and usefulness than other features. As might have been expected, IUPAC participants had greater interest in the coverage of IUPAC publications and reports than did subscribers and library readers. The rating is an index based on the number of 1st, 2nd . . . 5th choices by questionnaire respondents. The maximum possible rating is 4.0 (corresponding to all 1st choice); the lowest possible rating is 0.0 (all 5th choice); and 2.0 is a median value.

vacuum in the chemical literature, and many chemical societies and conference organizers purchased reprints to give their conference lecturers. About 5000 reprints were sold, of which a substantial fraction were purchased in small batches directly from the IUPAC Secretariat. The article has been translated into French and Russian, and reproduced in *L'actualite chimique* and *Khimija i Zhizn*. It will shortly be published in Italian in *La Chimica e le Industria*.

This response pointed to a real need for similar articles providing practical advice to help chemists do the things—other than chemistry—on which they spend much of their time and effort. A subsequent article, "Writing technical articles to be read and understood", also elicited a vigorous response. The original stock of 1000 reprints was completely sold, and orders and enquiries continue to arrive at the IUPAC Secretariat. Journal editors in Italy and Romania have requested (and been granted) permission to translate and reproduce the article. A third article, "The chemist in court", provides advice for the growing number of chemists being called to present their analysis results as legal evidence. The most recent article in this series (published in this issue) describes simple methods to obtain high-quality photographs of laboratory apparatus and specimens to record experimental information, and to add interest and meaning to research papers and lectures. Future "how to" articles might deal with searching the chemical literature and applying for patents.

What the questionnaire results imply is that readers do not prefer any general *type* of article, but judge each article on its own. One questionnaire respondent (an IUPAC participant) specifically stated, "I find it difficult to rate my preference according to the topics listed. It all depends on the quality of the contributions". He continued, "On the whole, the information in *Chemistry International* is interesting and useful. The proportion of the various topics appears to be well balanced".

For subscribers, library readers and some IUPAC Commission members, *Chemistry International* does apparently perform a function that is not fulfilled by other publications. One library reader responded, "Your magazine is excellent! There is no, to the best of my knowledge, scientific news magazine which presents interesting, novel topics so concisely". Another wrote, "Very interesting—your magazine seems to fill a void within the chemical literature and I am looking forward to your next issue." What evidently appeals to many readers is its light, easy-to-read style of writing and presentation. One IUPAC participant stated, "I feel that reading *Chemistry International* is a fruitful and pleasant experience". Others remarked, "Enjoy way of writing", and "Please continue in the way you are already going".

One IUPAC participant felt that the black borderlines and grey pages imparted a "heavy appearance, but another remarked, "the layout is very attractive and easy to read". Among the questionnaire responses was a request from the editor of a clinical chemistry journal for permission to reproduce an article in his journal, and a generous offer from the editor of a six-volume Chemical En-

cyclopaedia (*Rompps Chemie Lexikon*) to provide the IUPAC Secretariat with a complimentary set.

If we were to ask what type of individual subscribes to *Chemistry International*, the only answer we could infer with reasonable confidence is: those who like it enough to buy it. There may be a substantial number of chemists throughout the world who *would* subscribe if they were familiar with the magazine, but there seems to be no economic way to reach this diffuse group. In one case, the Royal Swedish National Academy of Sciences generously agreed to buy (at cost) 5000 sample copies of *Chemistry International* and distribute these copies to their member chemists. This was the only intensive promotion effort conducted in any one country, and it is therefore not surprising that there are more individual subscribers in Sweden (about 60) than in any other country. This response indicates that a massive international advertising campaign directed at chemists in all countries could induce 10,000 individuals to subscribe, more than enough for the magazine to be financially self-supporting. However, such a promotion effort would require a huge investment and would probably not generate sufficient subscription revenue to recover the cost of mailing sample copies or brochures.

Several factors mitigate against successful promotion of a magazine like *Chemistry International*. In most Western countries, the tendency for chemists to buy their own copies of chemistry journals has been declining steadily for at least a decade (reflecting a markedly different attitude among chemists who have graduated within the last 15 years). One can expect that in another 10 - 15 years, few chemists will subscribe to any chemistry publications other than their national chemistry magazine (to which they subscribe indirectly, by paying membership dues to their national chemistry society). Furthermore, while *Chemistry International* would likely appeal to many chemists in the Third World, individuals and libraries in these countries have very limited funds for purchasing imported publications. Foreign publications are generally not purchased, but obtained through exchange for local chemistry journals. Although a number of enquiries have been received from developing countries, sample copies requested and a few exchange arrangements made, there has not been (as of summer 1981) even one individual subscriber to *Chemistry International* in the Third World.

The conclusion that I (the Editor) have drawn from the *Chemistry International* experiment is that, if a publication is to be economically self-supporting, its content must be aimed at a specific market (a group of people that are willing to pay for it). While there does appear to be a **need** for *Chemistry International*, there does not appear to be an accessible **market**.

Nearly three years after the first issue of *Chemistry International* appeared, it is still not clear whether a chemistry news magazine of this type is the best information medium through which IUPAC can increase awareness of its activities among chemists throughout the world. The need for such a communications link will become more acute in 1983, when individual chemists are invited—for the first

time—to become Affiliate Members of IUPAC (see “Basis for individual IUPAC membership approved at General Assembly in Belgium” in previous issue of *Chemistry International*). Certainly, some type of news magazine or news letter will be required if IUPAC is to act as a coordinated centralized body, and not simply as a loose confederation of Commissions and Committees pursuing their own tasks.

An important turning point is approaching for *Chemistry International*, and for IUPAC. The trial period of *Chemistry International* is drawing to its end, and I have already decided to leave the post of Editor and emigrate to Australia. IUPAC must now decide whether to continue *Chemistry International*, to alter its form, or to replace it by an entirely different information medium.

OFF THE PRESS

Recent IUPAC publications

Recent advances in analytical spectroscopy

This volume of proceedings contains 26 papers selected from the invited lectures at the 9th International Conference on Atomic Spectroscopy and 12th Colloquium Spectroscopicum Internationale. The joint meeting was held 4 - 8 September 1981 in Tokyo, Japan. The scientific programme encompassed the entire field of analytical spectroscopy and its applications: Plasma emission spectrometry, DC arc, spark and other emission spectrometry; Hydride generation technique for atomic spectrometry; Furnace atomic absorption spectrometry; Zeeman atomic absorption spectrometry; Atomic spectrometric detection systems for separation analysis; Atomic fluorescence and scattering spectroscopy; Flame atomic absorption spectrometry; Spectroscopy for chemical state analysis; Spectroscopy for surface and interface analysis; Computers in analytical spectroscopy; Recent developments in laser spectroscopy; Application to life science, Environmental and geochemical applications; X-ray analysis; UV - VIS spectroscopy; IR and Raman spectroscopy; Magnetic resonance spectroscopy; Mass spectrometry; and Photoacoustic spectrometry.

The 336 page hard-cover proceedings volume, edited by K. Fuwa, will be available in April for £37 (US\$ 75).

Collaborative interlaboratory studies in chemical analysis

There is great interest throughout the chemical sciences in standardization and validation of analytical methods that are the basis for commercial specifications and for legal enforcement of standards dealing with human health, animal welfare and environmental quality. The area covered is extensive, ranging from agricultural produce and processed food to clinical chemistry and pharmaceutical supplies, industrial materials and the quality of air and water. Standards methods are now developed by many professional organisations on both a national and international level. Those concerned represent the professional interests of industry, commerce,

national governments and intergovernmental organisations, and teaching and research institutions throughout the world. There are now several national and international organisations whose sole or main objectives are the development of such methods as the basis of trade and, where necessary, the enforcement of regulatory or other standards of purity or performance.

It is obviously desirable that the standards and analytical methods developed in this manner should be compatible with one another. Different standards for the same thing should, so far as possible, be interchangeable. This book contains 29 papers delivered at the International Symposium on Harmonization of Collaborative Studies, held in Helsinki, Finland, 20 - 21 August 1981. At that meeting, organized by IUPAC, many of the international organizations concerned with the development of standard methods of analysis met for the first time. They also met with representatives of the three IUPAC Sponsoring Divisions concerned with collaborative studies—the Analytical, Applied and Clinical Chemistry Divisions.

The need for adopting a harmonized approach to the definition of the basic descriptive parameters of analytical methods was clearly recognized, as was the critical role of IUPAC and the International Organization for Standardization (ISO).

At the conclusion of the meeting, recommendations were made to Presidents of the three IUPAC Divisions. These will form the basis for future developments in this important field.

Drs. Harold Egan and Tom West edited the 178 page soft-cover volume. The book is scheduled for publication in April, and will be available for £25 (or US\$ 50).

Techniques de Dosage des Mycotoxines

This 54 page soft-cover report is a compilation and French translation of IUPAC reference methods for the analysis of aflatoxins and ochratoxins in various food products. The six reference methods have been translated and reproduced by the Food and Agriculture Organization (FAO) at Via delle Terme di Caracalla 00100, Rome, Italy, and may be obtained from Mr. K. O. Herz of the FAO Food Standards and Food Science Service.

CONFERENCES

IUPAC meetings are indicated in bold type

Additional information from address in parenthesis

1982

MOLTEN SALTS

May 24 - 28. EUCHEM Conference on Molten Salts. France.

(Dr. M. Gaune-Escard, Laboratoire de Dynamique et Thermophysique de Fluides, Universite de Provence, Centre de Saint-Jerome, Rue Henri Poincare, 13397 Marseille, Cedex, France.)

COMPUTERS IN CHEM. ENGINEERING

May 25 - 27. CHEMCOMP 82: Symposium on Chemical Process Analysis and Design using Computers. Antwerp, Belgium.

(Symposium CHEMCOMP 82, c/o K.VIV, Jan Van Rijswijcklaan 58, B-2000, Antwerp, Belgium.)

PHARMACOLOGY

May 25 - 28. 3rd Southeast Asian and Western Pacific Regional Meeting of Pharmacologists. Bangkok, Thailand.

(Secretariat, Department of Pharmacology, Faculty of Science, Mahidol University, Bangkok 4, Thailand.)

CATALYSIS

May 26 - 29. 8th Canadian Symposium on Catalysis. Waterloo, Ontario, Canada.

(Prof. R. R. Hudgins, 8th Canadian Symposium on Catalysis, Department of Chemical Engineering, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada.)

GEOCHEMISTRY

May 27 - 28. Meeting on Hydrothermal Phenomena Associated with Granitic Rocks of Europe. London, UK.

(Dr. A. H. Franklin, Department of Geology, Imperial College, London SW7 2BP, UK.)

CHEMISTRY/CANADA

May 30 - June 2. 65th Chemical Conference and Exhibition of The Chemical Institute of Canada. Toronto, Ontario, Canada.

(The Chemical Institute of Canada, 151 Slater Street, Suite 906, Ottawa, Ontario K1P 5H3, Canada.)

REACTIONS OF ONE CARBON MOLECULES

May 31 - June 3. International Symposium on Catalytic Reactions of One Carbon Molecules. Belgium.

(Dr. R. Schoonheydt, Centrum voor Oppervlakte- en Colloidale Scheikunde, KU Leuven, De Croylaan, 42, B-3030 Heverlee (Leuven) Belgium.)

PHOTOCHEMICAL DEVICES

May/June. Symposium on Photochemical Devices. Toronto, Canada.

(Dr. R. O. Loutfy, Xerox Research Center of Canada, 2480 Dunwin Drive, Mississauga, Ontario L5L 1J9, Canada.)

ANTIBIOTIC RESISTANCE

June. 5th International Symposium on Resistance to Antibiotics. Smolenice, Czechoslovakia.

(Slovak Medical Society, Mickiewiczova 18 883 22 Bratislava, Czechoslovakia.)

CARBOHYDRATE SYNTHESIS

June. EUCHEM Conference on Synthesis of Low Molecular Weight Carbohydrates of Biological Significance. Sweden.

(Prof. Per J Garegg, Department of Organic Chemistry, Arrhenius Laboratory, University of Stockholm, S-106 91 Stockholm, Sweden.)

ZIRCONIUM

June. 6th International Conference on Zirconium. Vancouver, Canada.

(Meetings Department, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, USA.)

CHLORINE

June 2 - 4. International Chlorine Symposium. London, UK.

(The Conference Secretariat, Society of Chemical Industry, 14/15 Belgrave Square, London SW1X 8PS, UK.)

ATMOSPHERIC CHEMISTRY

June 6 - 8. International Symposium on Chemical Kinetics Related to Atmospheric Chemistry. Japan.

(Dr. H. Akimoto, Division of Atmospheric Environment, National Institute for Environmental Studies, P.O. Tsukubagakuen, Ibaraki 305, Japan.)

ISOTOPICALLY-LABELLED COMPOUNDS

June 6 - 11. International Symposium on the Synthesis and Applications of Isotopically Labeled Compounds. MI, USA.

(Dr. Alexander Susan, Scientific Secretary, International Symposium on the Synthesis and Applications of Isotopically Labeled Compounds, Midwest Research Institute, 425 Volker Boulevard, Kansas City, MI 64110, USA.)

CHEMICAL ENGINEERING

June 6 - 12. 20th Chemical Engineering Exhibition Congress and the International Meeting of Chemical Engineering. (ACHEMA 82): Chemical engineering, corrosion and biotechnology. Frankfurt am Main, Federal Republic of Germany.

(DECHEMA, Postfach 97 01 46, D-6000 Frankfurt am Main, Federal Republic of Germany.)

SOLID-STATE CHEMISTRY

June 7 - 9. 2nd European Conference on Solid-State Chemistry. Eindhoven, Netherlands.

(Dr. H. J. M. Heijligers, Eindhoven University of Technology, POB 513, 5600 MB Eindhoven, The Netherlands.)

AGROCHEMICALS

June 7 - 11. International Symposium on Agrochemicals: Fate in Food and the Environment Using Isotope Techniques. Rome, Italy.

(Mr. Robert Najjar, Conference Service Section, International Atomic Energy Agency, P.O. Box 100, A-1400 Vienna, Austria.)

CONFERENCES 1982

INDUSTRIAL MICROORGANISMS

June 7 - 11. 4th International Symposium on the Genetics of Industrial Microorganisms. Kyoto, Japan.
(GIM Japan National Committee, c/o Microbiology Research Foundation, 2-4-16 Yayoi, Bunkyo-Ku, Tokyo 113, Japan.)

LIQUID CHROMATOGRAPHY

June 7 - 11. 6th International Symposium on Column Liquid Chromatography. Philadelphia, PA, USA.
(R. A. Barford, ERRC-SEA, U.S. Department of Agriculture, 600 East Mermaid La., Philadelphia, PA 19118, USA.)

HYDROGEN ENERGY

June 13 - 17. 4th World Hydrogen Energy Conference. Los Angeles, CA, USA.
(Dr. W. D. van Vorst, Chairman International Association for Hydrogen Energy, POB 248266, Coral Gables, FL 33124, USA.)

QUANTUM CHEMISTRY

June 14 - 19. 4th International Congress in Quantum Chemistry. Uppsala, Sweden.
(Uppsala Quantum Chemistry Group, Box 518, S-751 20 Uppsala, Sweden.)

IONIZED ATOMS

June 14 - 27. NATO Advanced Study Institute course on Atomic Physics of Highly Ionized Atoms (S.82/35). Cargese, France.
(Prof. R. Marrus, Physics Department, University of California, Berkeley, CA 94720, USA.)

POLYMER LATEX & EMULSIONS

June 15 - 17. International Conference on Polymer Latex and Emulsions. London, UK.
(Mr. R. H. Craven, Plastics and Rubber Institute, 11 Hobart Place, London SW1W 0HL, UK.)

ENZYMES

June 16 - 17. Discussion Meeting on Industrial and Diagnostic Enzymes. London, UK.
(Miss C. A. Johnson, The Royal Society, 6, Carlton House Terrace, London SW1Y 5AG, UK.)

ANAEROBIC WASTEWATER TREATMENT

June 16 - 18. Specialized Seminar on Anaerobic Treatment of Wastewater in Fixed Film Reactors. Copenhagen, Denmark.
(Prof. Poul Harremoës, Department of Sanitary Engineering, Building 115C, Technical University of Denmark, DK-2800 Lyngby, Denmark.)

ANALYSIS OF AIRBORNE CARCINOGENS

June 16 - 18. 3rd Symposium on Environmental Analytical Chemistry, Airborne Mutagens & Carcinogens. UT, USA.
(Delbert J. Eatough, 267 FB, Thermochemical Institute, Brigham Young U, Provo, UT 84602, USA.)

SPECTROSCOPY/CHROMATOGRAPHY

June 17 - 18. World Spectroscopy/Chromatography Conference. Nice, France.
(Alena Enterprises of Canada, 209 Dover Road, Cornwall, Ontario, Canada.)

MASS SPECTROMETRY

June 20 - 23. International Conference on Chromatography & Mass Spectrometry in Biomedical Sciences. Italy.
(Alberto Frigerio, Italian Group for Mass Spectrometry in Biochemistry & Medicine, Via Eritrea 62, 20 157 Milan, Italy.)

CARBOHYDRATE SYNTHESIS

June 20 - 24. EUCHEM Conference on Synthesis of Low Molecular Weight Carbohydrates of Biological Significance. Stockholm, Sweden.
(The Swedish National Committee for Chemistry, Upplandsgatan 6 A, 1 tr, S-111 23 Stockholm, Sweden.)

MEDICINAL CHEMISTRY

June 20 - 24. Medicinal Chemistry Symposium. Toronto, Canada.
(Leslie Humber, North American Medicinal Chemistry Symposium, c/o Ayerst Laboratories, P.O. Box 6115, Montreal, Quebec H3C 3J1, Canada.)

RADIOPROTECTORS & ANTICARCINOGENS

June 21 - 24. 1st International Conference on Radioprotectors and Anticarcinogens. Gaithersburg, MA, USA.
(Michael Simic, C216 Radiation Physics Building, National Bureau of Standards, Washington, DC 20234, 301/921-2374, USA.)

POLYHALOGEN COMPOUNDS

June 21 - 25. 4th International Symposium on Polyhalogen Compounds. Wroclaw, Poland.
(Prof. dr. hab. inz. Ryszard T. Sikorski, Institute of Organic and Polymer Technology, Technical University of Wroclaw, Wybrzeze Wyspianskiego 27, 50-370 Wroclaw, Poland.)

COMPOUNDS OF TRANSITION ELEMENTS

June 21 - 25. 7th International Conference on Solid Compounds of Transition Elements. Grenoble, France.
(E. F. Bertaut, C.N.R.S., Laboratoire de Cristallographie, 166 X, 38042 Grenoble Cedex, France.)

CRUDE OIL RECOVERY

June 21 - July 4. NATO Advanced Study Institute course on Heavy Crude Oil Recovery (S.82/30). METU, Ankara, Turkey.
(Prof. E. Okandan, Mining & Petroleum Engineering Department, METU, Ankara, Turkey.)

STORAGE OF BULK CHEMICALS

June 22 - 24. 4th International Conference and Exhibition on the Transportation Handling and Storage of Bulk Chemicals—MariChem 82. Amsterdam, Netherlands.
(Conference Secretariat, 2 Station Road, Rickmansworth, Herts WD3 1QP, UK.)

QUANTUM ELECTRONICS

June 22 - 25. 12th International Quantum Electronics Conference. Munich, Federal Republic of Germany.
(K. Hohla, Max Planck Institute für Quantenoptik, P.O. 1513 8046 Garching, Federal Republic of Germany.)

SOLID/LIQUID INTERFACES

June 22 - 30. 6th International Summer Conference on Chemistry of Solid/Liquid Interfaces including the International Symposium on Precipitation and Interfacial Phenomena in Mineralization in Biological or Biopolymer Matrices. Cavtat/Dubrovnik, Yugoslavia.
(Dr. Velimir Pravdić, VI Summer Conference Chemistry, "Rudjer Bosković" Institute, POB 1016, YU 41001 Zagreb, Yugoslavia.)

CONFERENCES 1982

ENVIRONMENTAL POLLUTION

June 28 - 29. 3rd European Conference on Environmental Pollution. Nice, France.
(Alena Enterprises of Canada, 209 Dover Road, Cornwall, Ontario, Canada.)

POLYMER-SUPPORTED REAGENTS

June 29 - July 1. International Symposium on Polymer-Supported Reagents in Organic Chemistry. Lyon, France.
(Dr. G. Gelbard, Laboratoire des Matériaux Organiques du CNRS, B.P. No. 24, F-69390 Vernaison, France.)

POLYMER COLLOIDS

June 29 - July 12. NATO Advanced Study Institute course on Polymer Colloids (S.82/1). Bristol, UK.
(Dr. G. W. Poehlein, School of Chemical Engineering, Institute of Technology, Atlanta, GA 30332, USA.)

MEDICAL CHEMISTRY

July. 18th International Meeting on Medicinal Chemistry. Rennes, France.
(Prof. J. Huet, Faculté de Pharmacie, Laboratoire de chimie pharmaceutique, Avenue du Professeur L. Bernard, F-35043, Rennes Cedex, France.)

SOLUTE - SOLVENT INTERACTIONS

July 4 - 10. 6th International Symposium on Solute - Solute - Solvent Interactions. Minoo, Osaka Prefecture, Japan.
(Prof. Hitoshi Ohtaki, Department of Electronic Chemistry, Tokyo Institute of Technology at Nagatsuta, Nagatsuta-cho, Midori-ku, Yokohama, 227 Japan.)

REACTION MECHANISMS

July 5 - 9. 3rd International Conference on Mechanisms of Reactions in Solution. Canterbury, UK.
(Dr. John F. Gibson, Secretary (Scientific), The Royal Society of Chemistry, Burlington House, London W1V 0BN, UK.)

INORGANIC STEREOCHEMISTRY

July 6 - 9. International Conference on Inorganic Stereochemistry. University of Reading, UK.
(Dr. J. F. Gibson, The Royal Society of Chemistry, Burlington House, London W1V 0BN, UK.)

COMPUTERS IN CHEMICAL RESEARCH

July 11 - 16. 6th International Conference on Computers in Chemical Research and Education (ICCCRE). Washington, DC, USA.
(Dr. Stephen R. Heller, Chairman, 6th ICCCRE, EPA, MIDSD, PM-218, 401 M Street, SW, Washington, DC 20460, USA.)

PHYSICAL ORGANIC CHEMISTRY

July 11 - 16. 6th IUPAC Conference on Physical Organic Chemistry. Louvain-la-Neuve, Belgium.
(Prof. A. Bruylants, Université Catholique de Louvain, Laboratoire de Chimie Générale et Organique Bâtiment Lavoisier, 1 Place Louis Pasteur, B-1348 Louvain-la-Neuve, Belgium.)

PLANT TISSUE & CELL CULTURE

July 11 - 16. 5th International Congress of Plant Tissue & Cell Culture. Tokyo and Lake Yamana, Japan.
(Masatoshi Iwata, Faculty of Agriculture, University of Tokyo, Bunkyo-ku, Tokyo 113, Japan.)

LANTHANIDES

July 11 - 25. NATO Advanced Study Institute course on Systematics and the Properties of the Lanthanides (S.82/31). Braunlage, Federal Republic of Germany.
(Prof. S. F. Sinha, Hahn Meitner Institute, Glienicke Str. 100, 1000 Berlin 39, Federal Republic of Germany.)

CHITIN AND CHITOSAN

July 12 - 14. 2nd International Conference on Chitin and Chitosan. Sapporo, Japan.
(Dr. S. Hirano, Department of Agricultural Biochemistry, Tottori University, Tottori 680, Japan.)

MACROMOLECULES

July 12 - 16. IUPAC Macromolecular Symposium. Amherst, MA, USA.
(James C. W. Chien, Department of Polymer Science and Engineering, University of Massachusetts, Amherst, MA 01003, USA.)

ORGANIC COATINGS

July 12 - 16. 8th International Conference on Organic Coatings Science & Technology. Athens, Greece.
(Angelos V. Patsis, Coykendall Science Bldg., State University of New York, New Platz, NY 12561, USA.)

NATURAL PRODUCTS

July 13 - 15. International Symposium on Progress in Natural Product Chemistry. Nottingham, UK.
(Dr. John F. Gibson, The Royal Society of Chemistry, Burlington House, London W1V 0BN, UK.)

UNIVERSITY TEACHING

July 14 - 17. 8th International Conference on Improving University Teaching. Berlin, Federal Republic of Germany.
(Improving University Teaching, University of Maryland University College, University Boulevard at Adelphi Road, College Park, MA 20742, USA.)

CORRELATION ANALYSIS IN ORGANIC CHEMISTRY

July 18 - 23. 2nd EUCHEM Conference on Correlation Analysis in Organic Chemistry. Hull, UK.
(Dr. John F. Gibson, The Royal Society of Chemistry, Burlington House, London W1V 0BN, UK.)

SELECTIVE POLYMER SORBENTS

July 19 - 22. 23rd Prague Microsymposium "Selective Polymer Sorbents". Prague, Czechoslovakia.
(Dr. F. Svec, c/o Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského n.2, 162 06 Prague 616, Czechoslovakia.)

CONTROLLED RELEASE DRUGS

July 19 - 23. Summer Program on Controlled Release Technology—Polymeric Delivery Systems for Drugs, Pesticides & Foods. MA, USA.
(Director of Summer Session Office, Room E19-356, MIT, Cambridge, MA 02139, USA.)
July 25 - 28. 9th International Symposium on Controlled Release of Bioactive Materials. FL, USA.
(A. F. Kydonieus, Hercon Div., Health-Chem Corp., 1107 Broadway, NY 10010, USA.)

CONFERENCES 1982

NON-AQUEOUS SOLUTIONS

July 19 - 23. 8th International Conference on Non-Aqueous Solutions. Nantes, France.
(Pham Van Huong, Laboratoire de Spectroscopie Infrarouge et Raman, Université de Bordeaux I. 351 Cours de la Libération—33405, Talence, France.)

CONDUCTOR-ELECTROLYTE INTERFACES

July 25 - 30. International Conference on Electronic and Molecular Structure of Conductor - Electrolyte Interfaces. Logan, UT, USA.
(W. N. Hansen, Physics Department, Utah State University, Logan, UT, USA.)

PHOTOCHEMISTRY

July 25 - 30. 9th IUPAC Symposium on Photochemistry. Pau, France.
(Prof. J. Jousset-Dubien, Laboratoire de Chimie Physique A, Université de Bordeaux I, F-33405 Talence, France.)

TOXINS AND LECTINS

July 26 - 28. International Symposium on Toxins and Lectins. Pretoria, South Africa.
(Symposium Secretariat S 255, CSIR, P.O. Box 395, Pretoria 0001, South Africa.)

ADSORPTION

July 26 - 29. 2nd Trieste International Symposium on Statistical Mechanics of Adsorption. Trieste, Italy.
(International Centre for Theoretical Physics, 34100 Trieste, POB 586, Miramare Strada Costiera 11, Italy.)

MARINE NATURAL PRODUCTS

July 26 - 30. 4th International Symposium on Marine Natural Products. Tenerife, Spain.
(Prof. A. G. González, Department of Organic Chemistry, University of La Laguna, Tenerife, Canary Islands, Spain.)

ATOMIC SPECTROSCOPY

July 27 - 30. 14th Conference of the European Group for Atomic Spectroscopy. Liège, Belgium.
(Mr. N. Grevesse, BFS-Group, University of Liège, Sart Tilman B15, B-4000, Liège, Belgium.)

ION CHEMISTRY

August. EUCHEM Conference on Ionic Chemistry: Gaseous versus Solvent Ions. Italy.
(Prof. F. Cacace, Istituto di Chimica, Farmaceutica e Tossicologica Cattedra di Chimica Generale ed Inorganica, Università di Roma, Rome, Italy.)

ELECTRON PARAMAGNETIC RESONANCE

August 1 - 6. 5th International Symposium on Electron Paramagnetic Resonance. Denver, CO, USA.
(Gareth R. Eaton, University of Denver, Denver, CO 80208, USA.)

FLUORINE CHEMISTRY

August 1 - 6. 10th International Symposium on Fluorine Chemistry. Vancouver, Canada.
(F. Aubke, Department of Chemistry, U of British Columbia, 2036 Main Mall, Vancouver, BC V6T 1Y6 Canada.)

COAL CONVERSION

August 2 - 6. IUPAC International Coal Conversion Conference. Pretoria, South Africa.
(Symposium Secretariat, S.219, CSIR, POB 395, Pretoria 0001, Republic of South Africa.)

NATURAL PRODUCTS

August 2 - 7. 13th International Symposium on Chemistry of Natural Products. Pretoria, South Africa.
(Mrs Jeanne Beck, Symposium Secretariat - S.219, CSIR, POB 395, Pretoria 0001, Republic of South Africa.)

MARINE CHEMISTRY

August 2 - 13. Joint Oceanographic Assembly. Halifax, Canada.
(Mr. Leo O'Quinn, Executive Secretary, JOA-82, 240 Sparks Street, 7th Floor West, Ottawa, Ontario K1A 0E6, Canada.)

SOLAR ENERGY CONVERSION

August 8 - 13. 4th International Conference on Photochemical Conversion and Storage of Solar Energy. Jerusalem, Israel.
(Secretariat, 4th International Conference on Photochemical Conversion and Storage of Solar Energy, The Authority for Research and Development, Hebrew University of Jerusalem, Terra Sancta, Jerusalem 94266, Israel.)

RADIATION INSTRUMENTATION

August 9 - 13. International Conference on X-Ray and VUV Synchrotron Radiation Instrumentation. Hamburg, Federal Republic of Germany.
(Mr. B. Buras, Riso National Laboratory, DK-4000 Roskilde, Denmark.)

POLYMER SPECTROSCOPY

August 11 - 13. 6th European Symposium on Polymer Spectroscopy. Hameenlinna, Finland.
(J. Lindberg, Department of Wood & Polymer Chemistry, U of Helsinki, Meritullinkatu 1 A, SF-00170 Helsinki 17, Finland.)

BIOCHEMISTRY

August 15 - 21. 12th International Congress of Biochemistry. Perth, Australia.
(Prof. B. N. Preston, Biochemistry Department, Monash University, Clayton, Victoria 3168, Australia.)

EFFLUENTS OF COAL-FIRED PLANTS

August 16 - 18. International Conference on Coal-Fired Power Plants and the Aquatic Environment. Copenhagen, Denmark.
(Mr. P. Schjodtz Hansen, Director V K I (Water Quality Institute) 11, Agern Alle, DK-2970 Horsholm, Denmark.)

COAL CONVERSION

August 16 - 20. International Coal Conversion Conference. Pretoria, South Africa.
(The Symposium Secretariat S.244, International Coal Conversion Conference, Council for Scientific and Industrial Research, P.O. Box 395, 0001 Pretoria, Republic of South Africa.)

METALS AND ALLOYS

August 16 - 20. 6th International Conference on the Strength of Metals and Alloys. Melbourne, Australia.
(The Director, Australasian Institute of Metals, 191 Royal Parade, Parkville, Victoria 3052, Australia.)

SPECTROSCOPY

August 16 - 20. 13th Australian Spectroscopy Conference. La Trobe University, Melbourne, Australia.
(J. B. Peel, Department of Physical Chemistry, La Trobe University, Baundoora, Victoria 3083, Australia.)

CONFERENCES 1982

SYNTHETIC NUCLEIC ACIDS

August 16 - 20. International Conference on Synthetic Oligonucleotides in Molecular Biology. Uppsala, Sweden.

(Dr. J. B. Chattopadhyaya, Department of Microbiology, University of Uppsala, The Biomedical Center, Box 581, S-751 23 Uppsala, Sweden.)

ORGANIC CHEMISTRY

August 17 - 20. 2nd International Kyoto Conference on New Aspects of Organic Chemistry. Kyoto, Japan.)

(Zen-ichi Yoshida, IKCOC-2, Department of Synthetic Chemistry, Kyoto U, Yosida, Kyoto 606, Japan.)

ELECTRON MICROSCOPY

August 17 - 24. 10th International Congress of Electron Microscopy. Hamburg, Federal Republic of Germany.

(Dr. Schimmel, Batelle Inst. Postfach 900160, 6 Frankfurt M-90, Federal Republic of Germany.)

PLANETARY ATMOSPHERES

August 17 - 28. International Conference on Origin and Evolution of Planetary Atmospheres. Hamburg, Federal Republic of Germany.

(Mr. S. Ruttenberg, International Association of Meteorology & Atmospheric Physics Secretariat, NCAR, P.O. Box 3000, Boulder, CO 80307, USA.)

OXIDATION REACTIONS

August 18 - 22. 2nd International Specialists Meeting of the Combustion Institute on Oxidation. Budapest, Hungary.

(Dr. Tamas Vidoczy, Executive Secretary, Second International Specialists Meeting of the Combustion Institute on Oxidation, Central Research Institute for Chemistry, H-1525 Budapest, P.O. Box 17, Hungary.)

AGRICULTURAL ENGINEERING

August 21 - 23. Conference on Agricultural Engineering 1982—Resources: Efficient Use and Conservation. Armidale, Australia.

(The Conference Manager, Conference on Agricultural Engineering 1982, The Institution of Engineers Australia, 11 National Circuit, Barton, ACT 2600, Australia.)

BIOLOGICAL SCIENCE

August 22 - 27. General Assembly and Scientific Symposia of the International Union of Biological Sciences. Ottawa, Canada.

(Dr. I. J. McDonald, Secretary, CNC/IUBS, Division of Biological Sciences, National Research Council, Ottawa K1A 0R6, Canada.)

ORGANIC SYNTHESIS

August 22 - 27. 4th International Conference on Organic Synthesis. Tokyo, Japan

(Prof. Teruaki Mukaiyama, Department of Chemistry, Faculty of Science, The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113, Japan.)

CARBOHYDRATES

August 22 - 28. 11th International Carbohydrate Symposium. Vancouver, Canada.

(Dr. G. C. S. Dutton, Department of Chemistry, University of British Columbia, BC V6T 1Y6, Canada.)

THERMAL ANALYSIS

August 22 - 28. 7th International Conference on Thermal Analysis. Kingston, Ontario, Canada.

(Chairman, Organizing Committee, seventh ICTA, Dunlop Research Centre, Sheridan Park Research Community, Mississauga, Ontario L5K 1Z8 Canada.)

ATOMIC PHYSICS

August 23 - 27. International Conference on X-Ray and Atomic Inner-Shell Physics. Eugene, OR, USA.

(Mr. B. Crasemann, X-82 Conference, Physics Department, University of Oregon, Eugene, OR 97403, USA.)

CHEMISTRY/AUSTRALIA

August 23 - 27. 7th National Convention of The Royal Australian Chemical Institute. Canberra, Australia.

(Dr. J. H. Bradbury, Chairman, 7NC, Chemistry Department, Australian National University, Canberra, A.C.T., Australia.)

COORDINATION CHEMISTRY

August 23 - 27. 22nd International Conference on Coordination Chemistry. Budapest, Hungary.

(Prof. M. T. Beck, Institute of Physical Chemistry, Kossuth Lajos University, Debrecen 10, H-4010 Hungary.)

GAS KINETICS

August 23 - 27. 7th International Symposium on Gas Kinetics. Göttingen, West Germany.

(Prof. J. Troe, Institut für Physikalische Chemie der Universität Göttingen, Tammanstrasse 6, 3400 Göttingen, Federal Republic of Germany.)

MAGNETIC RESONANCE

August 23 - 27. 16th International AMPERE Congress: Magnetic Resonance and Related Phenomena. Poznan, Poland.

(Mr. J. Stankowski, Instytut Fizyki, Molekularnej ul Smoluchowskiego, 17/19, PL-60-179 Poznan, Poland.)

POLYMERS

August 23 - 27. 13th Australian Polymer Symposium. Canberra, Australia.

(D. R. Williams, Department of Chemical Engineering, University of Adelaide, G.P.O. Box 498, Adelaide 5001, South Australia.)

MULTINUCLEAR MAGNETIC RESONANCE

August 23 - September 3. NATO Advanced Study Institute course on The Multinuclear Approach to Magnetic Resonance (S.82/6). Stirling, Scotland, UK.

(Prof. J. B. Lambert, Department of Chemistry, Northwestern University, Evanston, IL 60201, USA.)

CHEMICAL ENGINEERING

August 24 - 26. 10th Australasian Conference on Chemical Engineering—CHEMECA '82. Sydney, Australia.

(The Conference Manager, The Institution of Engineers, Australia, 11 National Circuit, Barton ACT 2600, Australia.)

POLYMER STRUCTURE & PROPERTIES

August 29 - September 2. Symposium on the Interrelations between Processing, Structure & Properties of Polymeric Materials. Athens, Greece.

(Prof. P. S. Theocaris, Chair of Applied Mechanics, National Technical University of Athens, Athens, Greece.)

CONFERENCES 1982

PESTICIDE CHEMISTRY

August 29 - September 4. 5th International Congress of Pesticide Chemistry. Kyoto, Japan.
(Rikagaku Kenkyusho, The Institute of Physical and Chemical Research, 2-1 Hirosawa Wako-shi Saitama Pref 351, Japan.)

PLANT GROWTH

August 29 - September 4. 21st International Horticultural Congress. Hamburg, Federal Republic of Germany.
(21st International Horticultural Congress, Hamburg Messe und Congress GmbH, P.O. Box 30 23 60, D-2000 Hamburg 36, Federal Republic of Germany.)

MASS SPECTROMETRY

August 30 - September 3. 9th International Mass Spectrometry Conference. Vienna, Austria.
(Univ. Prof. Dr. J. F. Huber, Institute of Analytical Chemistry of the University of Vienna, Währingerstr. 38, A-1090 Vienna, Austria.)

MOLECULAR STRUCTURE

August 30 - September 3. 3rd Conference on Determination of Molecular Structure by Microwave Spectroscopy and Electron Diffraction. Tuebingen, Federal Republic of Germany.
(D. Christen, Institute of Physical and Theoretical Chemistry, University Auf der Morgenstelle 8, D-7400 Tuebingen, Federal Republic of Germany.)

THEORETICAL CHEMISTRY

August 30 - September 3. International Symposium on Theoretical Organic Chemistry. Dubrovnik, Croatia, Yugoslavia.
(Dr. Ante Graovac, Institute "R. Bosković", POB 1016, 41001 Zagreb, Yugoslavia.)

MYCOTOXINS AND PHYCOTOXINS

August 31 - September 2. 5th International Symposium (IUPAC) on Mycotoxins and Phycotoxins. Vienna, Austria.
(Prof. Palle Krogh, Department of Microbiology, Royal Dental College, Juliane Mariesvej 30², DK-2100 Copenhagen 0, Denmark.)

AIR - SEA GAS EXCHANGE

August/September. NATO Advanced Study Institute course on Air - Sea Exchange of Gases and Particles (S.82/2). USA.
(Dr. P. S. Liss, School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK.)

TRANSIENT SPECIES

Autumn. EUCHEM Conference on Short Lived Species in Inorganic Chemistry and their Stabilization. Federal Republic of Germany.
(GDCh-Geschäftsstelle, Postfach 90 04 40, 6000 Frankfurt/Main 90, Federal Republic of Germany.)

FOOD PROCESSING & POLLUTION

September. CIIA/METE Symposium on Food Industry and the Environment. Budapest, Hungary.
(Prof. J. Hollo, Central Research Institute for Chemistry, Budapest, Pf. 17, H-1525, Hungary.)

IONIZED GASES

September 1 - 3. 6th Europhysics Conference on the Atomic and Molecular Physics of Ionized Gases (ESCAMPIG). Oxford, UK.
(Dr. R. W. P. McWhirter, Rutherford Laboratory, Chilton, Didcot OX11 0QX, UK.)

ECOLOGY

September 2 - 8. International Congress of Ecology. Poland.
(Prof. S. Ulfstrand, Sec. Gen. INTECOL, Department of Zoology, Box 561, S-751 22 Uppsala, Sweden.)

CHEMICAL TECHNOLOGY

September 2 - 16. 5th International Exhibition "Chemistry-82" (dealing with chemistry and chemical technology in chemical and petrochemical production, industry, building, agriculture and everyday life). Moscow, USSR.
(V/O "Expocentr", CHEMIE-82, Sokolnitscheski Wal, 1-a, Moscow 107113, USSR.)

HORMONAL STEROIDS

September 5 - 10. 6th International Congress on Hormonal Steroids. Jerusalem, Israel.
(Secretariat, PO Box 29784, Tel Aviv 61 297, Israel.)

CHEMICAL STRUCTURE—BIOLOGICAL ACTIVITY

September 6 - 9. 4th European Symposium on Chemical Structure and Biological Activity: Quantitative Approaches. Bath, UK.
(Dr. J. C. Dearden, School of Pharmacy, Liverpool Polytechnic, Byrom Street, Liverpool L3 3AF, UK.)

PREPARATION OF HETEROGENEOUS CATALYSTS

September 6 - 9. 3rd International Symposium on the Scientific Bases for the Preparation of Heterogeneous Catalysts. Louvain-la-Neuve, Belgium.
(Prof. B. Delmon, Université Catholique de Louvain, Groupe de Physico-Chimie Minerale et de Catalyse, Place Croix du Sud 1, B-1348 Louvain-la-Neuve, Belgium.)

WATER SUPPLIES

September 6 - 9. 14th Congress of the International Water Supply Association. Zürich, Switzerland.
(International Water Supply Association, Hardhof 9, CH-8023, Zürich, Switzerland.)

HEAT TRANSFER

September 6 - 10. 7th International Heat Transfer Conference. München, Federal Republic of Germany.
(DECHEMA, Postfach 97 01 46, D-6000 Frankfurt, Federal Republic of Germany.)

ORGANIC SULPHUR CHEMISTRY

September 6 - 10. 10th International Symposium on the Organic Chemistry of Sulphur. University College of North Wales, Bangor, UK.
(Dr. J. F. Gibson, The Royal Society of Chemistry, Burlington House, London W1V 0BN, UK.)

PHOTOGRAPHIC SCIENCE

September 6 - 10. International Congress of Photographic Science. Cambridge, UK.
(Science Committee, Royal Photographic Society of Great Britain, c/o Research Division, Kodak Limited, Headstone Drive, Harrow HA1 4TY, UK.)

RAMAN SPECTROSCOPY

September 6 - 12. 8th International Conference on Raman Spectroscopy. Bordeaux, France.
(Prof. J. Lascombe, Université de Bordeaux 1, 351, cours de la Libération, 33405 Talence Cedex, France.)

IONS IN THE GAS PHASE

September 6 - 17. International Conference on Chemistry of Ions in the Gas Phase (Nato Advanced Study Institute). Vimeiro, Portugal.
(Prof. M. A. Ferreira, Chemistry Department, University of Lisbon, R. Escola Politecnica, 1294 Lisbon Codex, Portugal.)

CHEMICAL THERMODYNAMICS

September 7 - 10. 7th International Conference on Chemical Thermodynamics. London, UK.
(Prof. M. L. McGlashan, Department of Chemistry, University of College London, 20 Gordon Street, London WC1H 0AJ, UK.)

FOOD INDUSTRY—THE ENVIRONMENT

September 8 - 10. International Symposium on Food Industry and the Environment. Hungary.
(C.I.I.A. 35, Rue du General Foy, F-75008 Paris, France.)

AMERICAN CHEMICAL SOCIETY

September 12 - 17. 184th National Meeting of the American Chemical Society. Kansas City, MI, USA.
(A.T. Winstead, American Chemical Society, 1155 16th Street NW, DC 20036, USA.)

WOOD CHEMISTRY

September 13 - 15. The 1982 Canadian Wood Chemistry Symposium. Niagara Falls, Canada.
(Dr. Cyril Heitner, Pulp and Paper Research Institute of Canada, 570 St. John's Boulevard, Pointe Claire, Quebec, Canada H9R 3J9.)

CHROMATOGRAPHY

September 13 - 17. 14th International Symposium on Chromatography. London, UK.
(The Executive Secretary, Chromatography Discussion Group, Trent Polytechnic, Burton Street, Nottingham NG1 4BU, UK.)

COSMETICS

September 13 - 17. 12th Congress of the International Federation of Societies of Cosmetic chemists. Paris, France.
(Office of the Secretariat, Société Française de Cosmétologie, 44 rue de 22 Septembre, 92400 Courbevoie, France.)

REMOTE SENSING FROM SPACECRAFT

September 13 - 17. International Society for Photogrammetry and Remote Sensing. Toulouse, France.
(Groupement pour le Développement de la Télédétection Aérospatiale, 18 avenue Edouard-Belin, 31055 Toulouse Cedex, France.)

THERMODYNAMICS—CALORIMETRY

September 13 - 17. 2nd Czechoslovak Conference on Calorimetry. Liblice and Prague, Czechoslovakia.
(Prof. Dr. Ing. Jiri Pick, DrSc. Department of Physical Chemistry, Institut of Chemical Technology, 166 28 Prague 6, Suchbatarova 5, Czechoslovakia.)

CHEMICAL ENGINEERING

September 14 - 16. 3rd Meeting of the Chemical Engineers in Italy, Yugoslavia and Austria. Raiffeisenhof Graz, Austria.
(Prof. Dr. F. Moser, Institut für Grundlagen der Verfahrenstechnik, TU Kopernikusgasse 24, A-8010 Graz, Austria.)

FOOD TECHNOLOGY

September 18 - 23. 6th International Congress of Food Science and Technology. Dublin, Ireland.
(Dr. R. L. Joseph, C/O, An Foras Taluntais, Dunsinea, Castleknock, Co. Dublin, Ireland.)

ALUMINIUM

September 19 - 22. 2nd International Aluminium Congress. Monte Carlo, Monaco.
(Metal Bulletin Congresses Ltd, Park House, Park Terrace, Worcester Park, Surrey KT4 7HY, UK.)

CLINICAL BIOCHEMISTRY

September 19 - 24. 2nd Asian Pacific Congress of Clinical Biochemistry. Republic of Singapore.
(Secretariat Singapore Professional Centre, 129B Block 23, Outram Park, Singapore 316, Republic of Singapore.)

FOOD RESEARCH

September 20 - 23. IUFOST Symposium on Food Research and Data Analysis. Oslo, Norway.
(Dr. H. Martens, Norwegian Food Research Institute, P.O. Box 50, N. 1432, As-NLH, Norway.)

CARBON

September 20 - 24. 6th International Carbon and Graphite Conference. Imperial College, London, UK.
(The Conference Secretary, CARBON '82 (Sixth London International Carbon & Graphite Conference) Society of Chemical Industry, 14/15 Belgrave Square, London, SW1X 8PS, UK.)

MOLECULAR CRYSTALS

September 20 - 24. 10th Molecular Crystal Symposium. Canada. (Daniel Chartrand, Executive Secretary, 10th Molecular Crystal Symposium. National Research Council of Canada, Ottawa, Ontario, Canada K1A 0R6.)

BIOMASS UTILIZATION

September 20 - 30. NATO Advanced Study Institute Course on Biomass Utilization (S.81/23). W. Virginia, USA.
(Dr. H. Sobel, Biosources Digest, P.O. Box 1979, Santa Monica, CA 90406, USA.)

RADIATION CURING

September 21 - 23. 6th International Radiation Curing Conference. Chicago, USA.
(Susan E. Buhr, Association for Finishing Processes of SME, 1 SME Dr., POB 930, Dearborn, MI 48128, USA.)

FOLIC ACID DERIVATIVES

September 21 - 24. 7th International Symposium on Pteridines and folic acid derivatives. St. Andrews University, Scotland, UK.
(Prof. H.C.S. Wood, Department of Pure and Applied Chemistry, University of Strathclyde, 295 Cathedral Street, Glasgow G1 1XL, Scotland, UK.)

POLYMER CRYSTALS

September 21 - 24. 14th Europhysics Conference on Polymer Crystals—Structure and Morphology. Villafranca del Penedes, Spain.
(F. J. Balta Calleja, Instituto de Estructura de la Materia, Serrano, 119, Madrid 6, Spain.)

Chemistry International

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The International Union of Pure and Applied Chemistry (IUPAC), formed in 1919, is a voluntary, non-governmental, non-profit association of organizations, each of which represents the chemists of a member country.

Its objectives are:

to promote continuing co-operation among the chemists of the member countries;

to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;

to co-operate with other international organizations which deal with topics of a chemical nature;

to contribute to the advancement of pure and applied chemistry in all its aspects.

The membership of IUPAC presently comprises 43 countries, each represented by a national organization, such as an academy of science or research council.

NATIONAL MEMBER ORGANIZATIONS

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Australian Academy of Science (**Australia**)

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Associação Brasileira de Química (**Brazil**)

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National Research Council of Canada (**Canada**)

Chinese Chemical Society, and Chemical Society located in Taipei, China (**China**)

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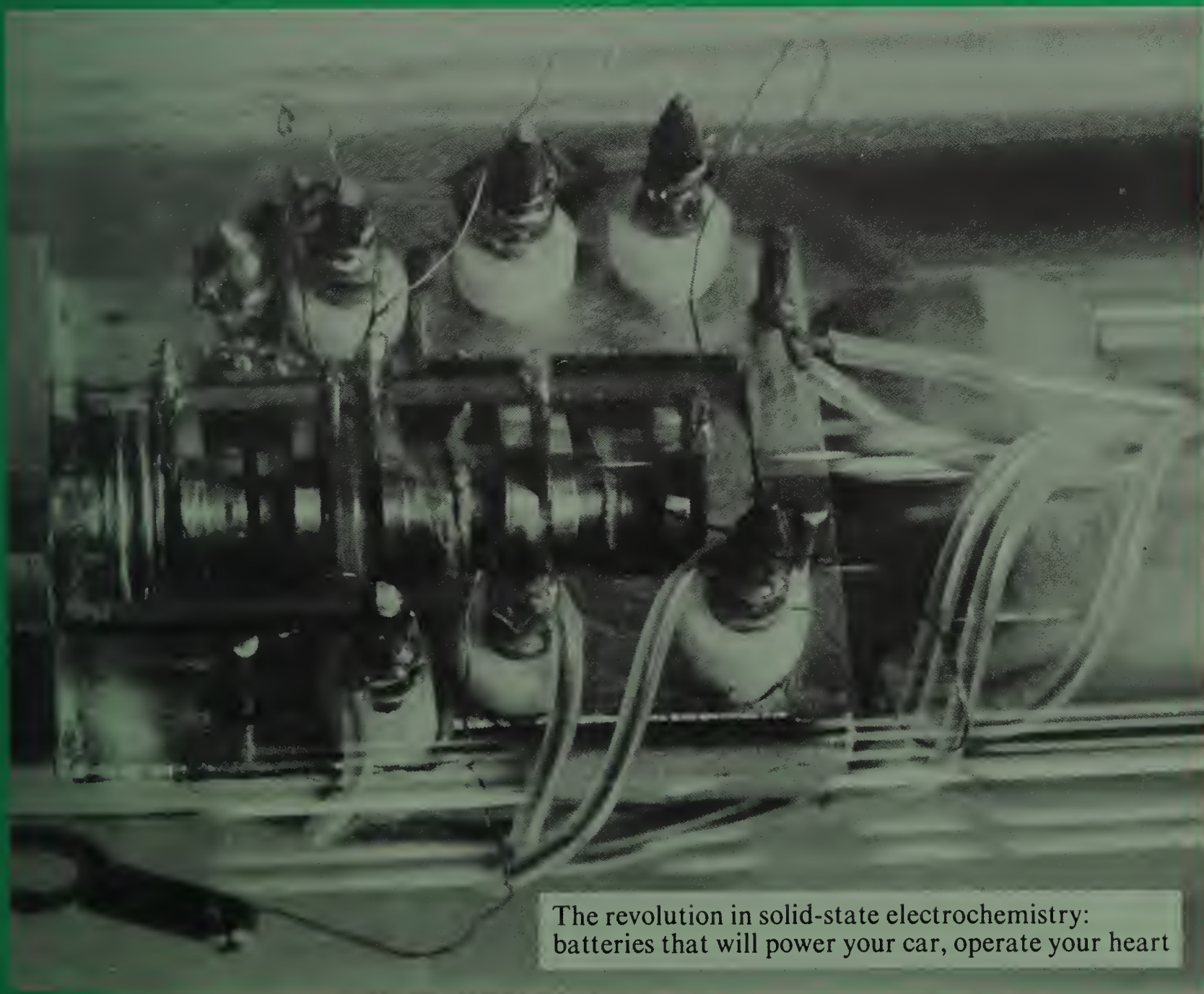
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Chemistry International

The news magazine of the International Union
of Pure and Applied Chemistry (IUPAC)



The revolution in solid-state electrochemistry:
batteries that will power your car, operate your heart



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Those wishing to write articles or propose topics for coverage in Chemistry International should write a brief letter to the Editor, explaining why the subject might be of wide interest or significance. Correspondence to the Editor should be sent to the IUPAC Secretariat, 2-3 Pound Way, Cowley Centre, Oxford OX4 3YF, UK.

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The ability to solve problems is fundamental for success in chemistry, believes chemical education researcher

The purpose of a university education is *not* simply to teach chemistry, asserted Professor Malcolm Frazer in his Nyholm Lecture to the Royal Society of Chemistry* but to enable students to *solve chemical problems*. After all, solving problems is what chemists actually do most of the time. A practicing chemist frequently encounters simple problems that take a few minutes to solve (like, how can I prevent my product solution from suddenly boiling out of the flask while the solvent is evaporated? or, how much 1 M HCl will be needed to neutralize the alkali in my sample?). Sometimes, the problems may be more complex (how can I confirm the identity of my reaction product?), or may involve many individuals working for months or years (should we develop a process to manufacture chemical A? How much would it cost to manufacture the product? Where should the plant be sited?).

Even if a chemistry student does not undertake a career in chemical research, but works in some related area—chemical engineering, marketing, management, or chemical sales—he will still be primarily concerned with solving problems. For this reason, Professor Frazer feels that a chemical education is excellent preparation for any technical career. He believes that developing the student's ability to

recognize and solve problems should be one of the goals of a university chemical education. Most chemists will not spend their entire career in the same field of specialization, but will diversify into new areas. They will need to expand, update and revise their initial understanding of chemistry, learning new experimental techniques and theoretical concepts. Their knowledge of chemistry will change, but they will always be solving problems.

Professor Frazer's argument has profound implications for chemical educators. It means that teaching chemistry should not be the ultimate goal of chemical education. Rather, the knowledge of chemical facts acquired by the students should provide a framework within which they can develop an analytical approach and problem-solving skills. Chemistry problems should not simply be a means to help students learn and assimilate facts, he argues. Rather, students should learn chemistry so that they can confidently deal with chemistry problems that will arise later in their careers.

Professor Frazer does not, however, minimize the importance of learning theoretical concepts and experimental techniques. He notes that a student cannot solve chemical problems if he doesn't understand the chemistry involved. Unless someone knows the

Try a different approach when you're stuck on a problem

No one problem-solving strategy is appropriate for all problems, or for all individuals. The following list presents some alternative problem-solving ideas. Some may seem contradictory, as indeed they are, as problems can be approached from many different — and sometimes, entirely opposite — directions. When you are stuck on a problem, try a different approach.

- (1) Work backwards from the goal, not forwards from the given information.
- (2) Make a guess at the solution, and then work backwards to see if the guessed solution is consistent with the available information.
- (3) Break down the problem into sub-goals and work at each separately. Do not try to cope with too much information at any one time.
- (4) Have a "brainstorm session". Write down all ideas for ways to solve the problem, no matter how foolish they might initially appear.
- (5) Check that all available information has been used, and that all other sources of information (memory, literature, experts, experiment) have been exhausted.
- (6) Try to obtain an overview of the problem, and see the situation as a whole.
- (7) Draw diagrams, verbalize the problem, convert a statement into a question or into a mathematical expression.
- (8) Forget about the problem for a while, and allow it to "incubate" in your mind.

information needed to solve a problem, or has learned how to obtain it, he cannot hope to successfully approach the problem—or even to understand it.

In real-life situations, success or failure depends not only on a person's ability to *solve* problems, but also on his ability to *recognize* them. When a student sets out to prepare a derivative by replacing one substituent on a parent compound, for example, he must recognize that other functional groups in the molecule might be attacked by the same reagents. For nearly everything that we do, there may be unanticipated problems or side effects.

On the other hand, many cases arise where a discovery or a new technique could provide a practical solution to an unsolved problem—if the discoverers are aware that the problem exists. One instance was the development, in the 1940s, of techniques for monitoring radioisotope tracers. These techniques were ideally suited for measuring the uptake of fertilizers from soil, although the first pioneers of nuclear chemistry did not realize that their technology could be applied for this purpose. They were unaware of the need to make such measurements, and did not know that monitoring fertilizer uptake had proven an intractable problem with other methods (see "The birth of nuclear chemistry created opportunities and danger" in the previous issue of *Chemistry International*). What was needed was contact between those individuals with the experience to recognize a problem, and those with the expertise to solve it. There have undoubtedly been many similar instances where the failure to recognize a problem has delayed the advance of science or led to inefficiency.

Usually, complex chemical problems cannot be solved by one individual. It is often necessary for decision-makers to work with many individuals with different backgrounds and outlooks. Successful solutions of the problem may require a team effort, with each person contributing knowledge and experience in his respective field of expertise.

The best way to develop problem-solving skills is through practice, but most chemistry courses present problems that differ from real-life situations in several important respects. For real problems, no one knows the answer in advance. Indeed, there might not be *any* solution to the problem. On the other hand, there may be several reasonable courses of action, of which the "best" choice depends on the experience and judgement of the decision maker.

It is important for chemical educators to choose problems that motivate the student, and simulate "real problems" that the student might actually expect to encounter. While it is essential that the problems challenge the student, the intention should be for students to succeed—not to fail. Unless a student (or indeed, anyone) periodically experiences the

satisfaction of successfully solving a problem, he will lose confidence and interest. The solution(s) to a problem should not be obvious, but on the other hand, all the information and reasoning required to solve the problem should be within the student's grasp. All too often, problems presented to students require that the student know some obscure piece of information. Most chemistry problems are designed to test or reinforce only those concepts that have recently been taught, and which are not yet secure in the student's mind.

There is a common tendency for teachers to ignore students who have obtained a correct solution. However, a student with the correct answer needs guidance and encouragement just as much as the student with an incorrect solution. Successful chemists reflect on their experiences. They learn from their mistakes *and* from their achievements. In the same way, students need to be shown what they can learn from their own solutions or attempted solutions. Of course, different people solve problems in different ways, and teachers should not impose pre-conceived notions about the correct way to solve a problem.

Professor Frazer demonstrated to his lecture audience how readily we impose our own pre-conceived ideas. He posed this problem to the audience: how would you determine the composition of a 1982 50 pence coin? He allowed a few moments for the audience to consider the problem. Most began to outline an experimental procedure for dissolving a coin, and performing an elemental analysis by atomic absorption spectroscopy. Professor Frazer suggested an alternative approach. A chemist confronted with this problem should, he maintained, make a telephone call to the chief chemical analyst at the British Mint. In this way, he could obtain a result that was at least as accurate as the chemist might measure himself, and would take much less time. If our goal were to solve the problem in the simplest, most direct way, then this would be the best solution to the problem.

Test your problem-solving skill

460 grams of nitrogen dioxide vapour are heated to 200°C in a closed vessel with a volume of 0.50 m³. The compound dissociates according to the following equation:



When equilibrium is attained, it is found that 30% of the NO₂ has dissociated. Calculate the density of the gas mixture.

Have you obtained a correct answer? Have you solved the problem in the simplest, most direct way? Turn overleaf to check your answer and your problem-solving strategy.

Check your problem-solving strategy

(answer to test problem on previous page)

This problem is far simpler than it initially appears to be. A person confronted with this problem has considerably more information available than he actually needs to solve it (as in many real-life problems). Many chemists assume that this is a typical equilibrium-type problem, and immediately calculate the concentrations of the three gaseous components when the re-

action is at equilibrium. This is entirely unnecessary—as becomes immediately apparent when the goal of the problem is identified. To calculate the density of the gas, one simply needs to know its total mass (stated to be 460 grams) and its volume (0.50 m^3). The density is therefore $460/0.50$, or 920 grams/m^3 .

A common mistake, Professor Frazer noted, is for chemists to assume, after a superficial reading, that the problem is of a particular type, and immediately jot down an equation or apply a well-established procedure for solving that type of problem. Successful problem solvers, on the other hand, set out to solve the problem only after they have clearly identified the goal that they are asked to achieve, and after they have obtained an overview of the situation.

Too often, the problems presented to students are artificial in nature. Only one answer is considered to be correct, and *that* has generally been determined in advance by the teacher or textbook author. Most of the information necessary to derive this answer is provided in the problem statement or has been presented in recent lectures. The student is not given the opportunity to recognize or define the problem. He/she gains no experience in deciding what information should be sought in the literature or obtained by experiment, and is not expected to choose the best solution among several plausible alternatives. There is no shortage of textbooks giving academic-type problems of this type, but few sources have been published which present problems as they really arise outside the classroom.

Professor Frazer's chemical education group at the University of East Anglia (in the UK) has developed a course aimed specifically at helping second-year honours students develop their problem-solving skills. Although the course deals with chemistry of non-transition elements, it is not intended primarily for students to learn chemistry (although, no doubt, they do). Rather, students are expected to apply their existing knowledge of organic and inorganic chemistry to solve problems.

The course has one introductory lecture, in which strategies of chemical problem solving are discussed. In each of the following course sessions, the students are presented with one carefully-chosen problem. Each contains one part for which there is only one correct answer,

and a second part for which there are several possible solutions. The students work individually on the problem for the first 20 minutes of a session. They are encouraged to write down all their ideas and guesses as they work at the problem. At the end of this period, they hand in a copy of their solution on carbonized paper (for which the chemistry and problem-solving strategy are later graded), and take the remaining copy into a group with three other students. The groups discuss each other's ideas for the next 20 minutes, after which a spokesman for each group presents their solution.

In developing the problem-solving course, Professor Frazer and other faculty members at the University of East Anglia took into account observations and conclusions made during their chemical education studies. They had found that having small groups of students teaching each other is an effective way to develop their confidence. Students are more willing to make guesses in the absence of a teacher. Members of a group are more likely to listen patiently to each other's ideas and learn from one another, than to learn from an "expert" who has solved the problem and is "looking back" from the solution.

Professor Frazer urges that teachers initially present problems in which the student need not handle more than a few pieces of information. As students acquire experience, they develop the ability to work with "chunks" of information and can handle many more facts. Once they become familiar with gas chromatography, for example, they can visualize a chromatograph as one piece of analytical information, rather than view it as a massive collection of data on peak areas, retention times and column operating conditions.

**Professor Frazer presented his Nyholm lecture at several universities in the UK during February and March 1982, and during the Annual Chemical Congress of the Royal Society of Chemistry (held in April).*

The photoelectron microscope reveals surface structure & chemical composition

The burgeoning interest in microelectronics and catalysts has created a strong impetus for the development of new techniques to analyse the surface of solids. In addition to obtaining detailed structural information through electron microscopes, researchers would like to determine the microscopic distribution of chemical compounds within a surface, or adsorbed on it. To do so, several modifications of a scanning electron microscope may be used (these are described in "Chemical analysis through the electron microscope" in the previous issue of *Chemistry International*). In each of these techniques, scanning a highly-focused electron beam across the surface induces the ejection of X-rays or Auger electrons, whose energies are characteristic of the element from which they originated. However, the high-energy incident electron beam used to probe the surface can destroy the very structure that the analyst wishes to examine. What is needed is a new form of microscopy which is sensitive to differences in chemical composition, but uses a less powerful and destructive type of radiation to probe the surface.

Stunning preliminary results of a technique that does exactly this was described by Dr. D. W. Turner at a meeting on *Microscopy of Solid Surfaces**. His group (at Oxford University) had developed a photoelectron microscope, which uses vacuum ultraviolet or soft X-rays to eject electrons of characteristic energies. Dr. Turner, one of the founders of photoelectron spectroscopy (whereby the energy spectrum of photoelectrons is measured), was very well aware that the energy of photoelectrons ejected from a surface reflects the chemical composition of the surface layer. However, formidable technical problems had to be solved before a practical photoelectron microscope could be built. For one thing, it is not feasible to focus vacuum ultraviolet radiation or X-rays to a point on the surface, as is done with the electron beam in a scanning electron microscope. Instead, Dr. Turner decided to irradiate *the entire surface* with the radiation beam, focus *all* the ejected photoelectrons onto an enlarged image, and allow only those photoelectrons with a pre-selected energy to strike a phosphor screen (forming a magnified picture of the surface).

It was not straightforward to build an instrument that could focus photoelectrons originating from the entire surface *and* transmit only those with a particular amount of kinetic energy. Devising an instrument that could meet both these requirements must have seemed an extra-ordinarily difficult task. In conventional electron focusing systems, the path of an elec-

tron (and its ultimate destination) is very much dependent upon its kinetic energy. Yet, the successful development of a photoelectron microscope required a simple device that could focus all electrons ejected from each point on the sample surface—with a wide range of velocities—onto the corresponding point on its magnified image.

Dr. Turner, who is a member of the IUPAC Commission on Molecular Structure and Spectroscopy, attacked the problem with an unusual approach. He devised an instrument which was far simpler than anyone might have expected. Rather than using an electric field to focus electrons, as is done in nearly all commercial electron spectrometers, Dr. Turner decided to use an extremely powerful magnetic field created by a superconducting magnet. In fact, some of the very first photoelectron spectrometers that Dr. Turner had constructed some 20 years ago had utilized weak magnetic fields (a few Gauss) to separate photoelectrons of different energies, and focus them onto an exit slit. However, because a superconducting electromagnet generates magnetic fields that are so much more powerful (80 000 Gauss), it exerts nearly complete control over the trajectories of the electrons. A photoelectron ejected from the sample, located in the central region of the magnetic field, is confined to move in the same direction as the magnetic lines-of-force. As electrons leave the central region of the electromagnet, they spread outwards as the magnetic field becomes less intense.

Eventually, the ejected photoelectrons impinge upon a phosphor screen, on which they form an enlarged "image" of the sample surface. Strictly speaking, the magnetic field does not "focus" the electrons, as do conventional magnetic or electrostatic fields. Rather, the magnetic field simply allows the electron beam to spread out in a completely controlled way, so that all electrons striking any point on the phosphor screen have originated from a corresponding point on the sample surface. The point at which an electron ultimately strikes the screen does *not* depend upon the energy with which it was ejected from the sample.

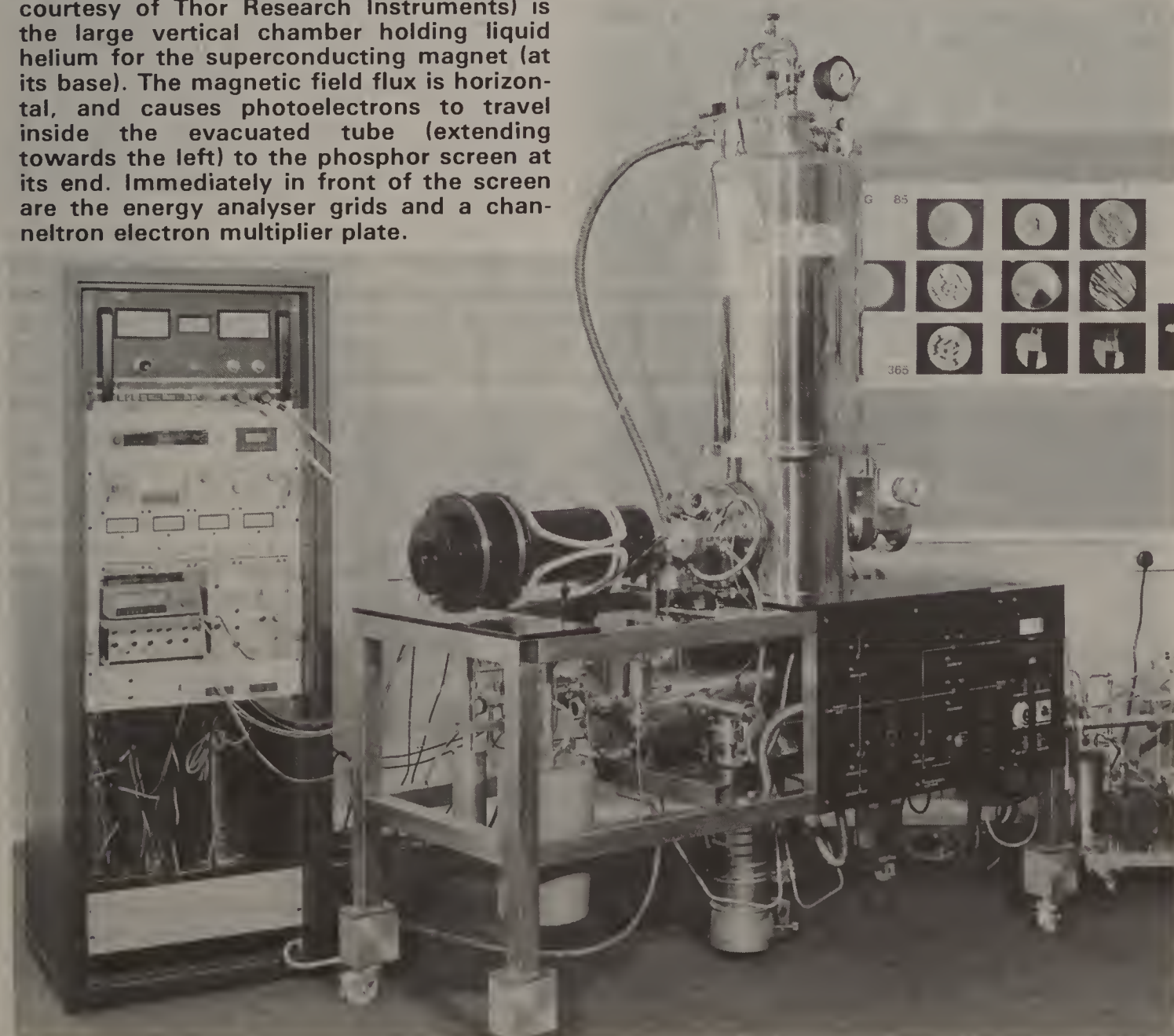
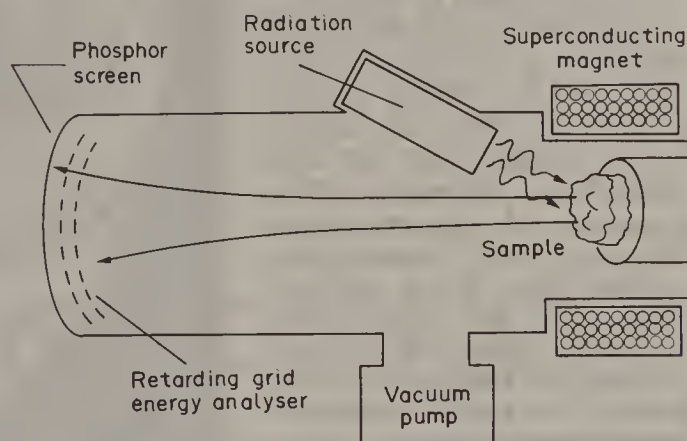
The trajectory that an electron is forced to follow, and where it eventually strikes the phosphor screen, is determined *only* by the original position on the sample surface from which it was ejected. Because the magnetic forces generated by the superconducting magnet are so powerful, the electrons are held very close to the magnetic field lines. Although an electron may be ejected with a substantial velocity component perpendicular to the magnetic field, it is confined within a tiny

orbit around a magnetic field line (these are imaginary lines travelling through space, indicating the direction of the magnetic field). An electron spirals around the magnetic field line with a corkscrew-like motion, making thousands of rotations during its flight to the phosphor screen. The diameter of the spiral is extremely small, but it does limit the maximum resolution which can be attained with the microscope. Electrons ejected from adjacent

areas on the sample surface, within one spiral diameter, could be projected to the same point on the image. The resolution of the photoelectron microscope is therefore determined by the kinetic energy of the photoelectrons and the strength of the magnetic field.

Photoelectrons ejected by vacuum ultraviolet radiation (so-called because the radiation is strongly absorbed by air, and must be transmitted through a vacuum) have only a few elec-

The main components of a photoelectron spectromicroscope are depicted in this schematic illustration. The sample is illuminated with vacuum ultraviolet or X-ray radiation, causing photoelectrons to be ejected with characteristic energies from those compounds present on the surface. The electrons are forced to travel in the direction of a powerful magnetic field, moving parallel away from the sample surface and then diverging outwards. When the electrons strike a phosphor screen, they form an enlarged visual image of the sample surface. By applying an electrical potential to the retarding grid energy analyser, the microscopist/analyst can examine the image formed by electrons with a particular energy (having originated from a particular compound on the surface). The most conspicuous component in the actual prototype instrument (shown in the photograph below, courtesy of Thor Research Instruments) is the large vertical chamber holding liquid helium for the superconducting magnet (at its base). The magnetic field flux is horizontal, and causes photoelectrons to travel inside the evacuated tube (extending towards the left) to the phosphor screen at its end. Immediately in front of the screen are the energy analyser grids and a channeltron electron multiplier plate.



A view of a silicon chip, seen through the photoelectron microscope at about $150\times$ magnification. The micrograph shows only those surface components which have a slightly elevated electrical potential, resulting from the application of a voltage to an external lead of the chip. Additional kinetic energy is imparted to photoelectrons ejected from these areas, which can then be selectively transmitted to the phosphor screen. The passage of lower-energy electrons, which have been ejected from those surface areas that are electrically insulated from the applied voltage, is blocked by the energy analyser (located immediately in front of the phosphor screen).



tron volts kinetic energy. One can thus expect to resolve features about one micron in size. This is comparable to the resolution of a good optical microscope (whose resolution is proscribed by the wavelength of visible light, and is also about one micron), and of course, is much less than can be achieved in an electron microscope.

The photoelectron microscope does provide, however, several outstanding advantages. One is its ability to examine rough or pitted surfaces with considerable variation in the height of surface features. A conventional optical microscope (or electron microscope) has an extremely limited "depth-of-field". The observer cannot clearly see those parts of the specimen that are below, or projecting above, the in-focus plane. The depth-of-field of any focusing device decreases at high magnification (for an explanation why this is so, see article on *Scientific Photography* in previous issue of *Chemistry International*). Even with a moderate magnification of about 100, the viewer can only observe structural details if they are no more than about one micron above or below the in-focus plane. He would need to refocus the microscope to examine features projecting above or recessed below the surface on which the microscope is initially focused. Viewing large areas of a rough, uneven surface would be tedious and time-consuming.

Not so with the magnetic projection photoelectron microscope, whose "depth-of-field" is virtually unlimited (in practical terms, at least 10 000 times greater than an optical microscope). This is a consequence of the magnetic field, which is most intense and very homogenous in the region where the sample is positioned. Photoelectrons ejected from a

deep-lying point on the sample do not spread out any more than those ejected from the tip of a projection. All photoelectrons are confined to travel in parallel paths (along the magnetic field lines) until they leave the central region of the magnetic field. There is no need to refocus the microscope to examine surface features at various elevations. Large specimens with rough surfaces can be scanned rapidly at high magnification.

A second feature that distinguishes the photoelectron microscope from optical magnifiers is that it only shows those features within a few atomic layers of the surface. Photoelectrons can only escape from atoms within 10 nanometres of the surface, as compared to light radiation, which usually passes through the entire thickness of the sample.

Perhaps the most important feature of the photoelectron microscope is its ability to distinguish surface features with different chemical composition. The kinetic energy of each photoelectron ejected from the sample surface depends upon the particular chemical compound from which it originated (according to the ionization energies of its molecular orbitals). Electrons ejected from one particular compound have different energies from photoelectrons ejected from other compounds. To transmit only those electrons of the desired energy (and thus, favour those ejected from a particular compound), an "energy analyser" is placed in front of the phosphor screen on which the visual image is formed.

The energy analyser allows those electrons of the pre-selected energy to reach the phosphor screen and generate a visual image, while blocking electrons with other energies. It functions as a highly-selective "energy window", through

which the viewer observes an image formed by electrons of the pre-selected energy. In developing the photoelectron microscope, Dr. Turner decided to employ one of the simplest energy analysers. It consists of two parallel metal grids placed perpendicular to the path of the electrons. An electrical potential is applied across the two grids, giving rise to an electric field which repels electrons entering the region between the two grids. All electrons with less energy than the repulsive potential are brought to a halt, and then driven back. These low-energy electrons cannot penetrate the electric field between the grids, while electrons with kinetic energy greater than the repulsive potential can punch through the electric field barrier.

A small alternating electrical signal is imposed on the retarding potential applied to the grids, causing a slight pulsation in the transmitted beam intensity. The variation in transmitted current is due to those electrons with kinetic energies very slightly less than the retarding potential voltage. Photoelectrons *with that particular energy* cause a modulation (or flickering) of the visual image on the phosphor screen. By electronic processing of the microscope picture formed on the screen, it is possible to extract and reproduce an image formed only by those photoelectrons ejected with this same energy from the sample surface.

The energy of photoelectrons ejected by vacuum ultraviolet radiation (VUV) reflects the molecular orbitals of the compound from which they originate, and the vibrational energy levels of the molecule. Electrons ejected from most compounds have a relatively broad range of energies, which often overlaps the energy distribution of photoelectrons ejected from other compounds. Thus, the image formed by a

photoelectron microscope using VUV radiation provides some *contrast* between areas of different chemical composition, but it is not chemically-specific. One cannot, for example, tune the instrument to show an image produced solely by calcium atoms at the surface of the sample. To do *that*, one needs to use photoelectrons ejected from inner-shell atomic orbitals (whose ionization energies are not affected by vibration of the molecule). Photoelectrons ejected from these orbitals have energies which are characteristic of the particular element from which they originate.

Photons of VUV radiation do not have enough energy to eject electrons from inner-shell orbitals. To obtain a chemically-specific photoelectron image requires the use of X-rays. Dr. Turner had suspected that the same instrument might be used to focus and analyse photoelectrons ejected by X-rays. Indeed, the same approach would *have* to be used to obtain X-ray photoelectron microscope pictures, since it is also not feasible to produce a focused beam of X-rays that could be scanned across the sample surface. If anything, most X-ray sources produce a radiation beam that is more diffuse than the VUV radiation produced by discharge tubes. There was considerable doubt whether a moderate-power X-ray source could eject sufficient numbers of photoelectrons to form good-quality microscope images.

These doubts turned out to be completely unfounded, Dr. Turner explained in his lecture. Only two days before, his research group had successfully obtained the first X-ray photoelectron microscope pictures. They were, in fact, able to obtain a sufficiently bright microscope picture on the phosphor screen by mounting a small, low-power X-ray source im-

Immersing an iron sulfide mineral in gold chloride solution failed to produce a uniform coating of gold, as is immediately apparent from the photoelectron microscope image of the mineral surface. The thin gold coating (which appears white in this photograph) is easily distinguished from the exposed surface of the mineral (here, appearing black) because of the much higher yield of photoelectrons ejected from the gold surface by vacuum ultraviolet radiation. Such a thin layer of gold (only about 5 nanometres thick) would be virtually transparent to light. Consequently, a microscopist using a conventional light microscope would have great difficulty observing the gold coating, and would need to refocus the microscope to examine recessed and projecting areas of the coarse sample surface. (Photoelectron micrograph at 25X magnification, provided courtesy of Thor Instrument Company.)



mediately above the sample surface.

The combination of magnetic focusing and energy selection by a retarding grid analyser provides extremely high electron transmission efficiency, enabling bright images to be formed with even a relatively weak source of radiation. All photoelectrons emitted from the sample surface are projected by the magnetic field onto the retarding grid analyser. Expansion of the electron beam provides an ideal "pre-conditioning" for energy analysis. Because of the high magnification of the magnetic collimation system, the electron beam is projected onto the retarding grids with a very narrow angular divergence. Consequently, it is possible to obtain high energy resolution—without imposing an aperture or limiting the angular spread of electrons accepted into the analyser.

The electron beam transmitted through the energy analyser (whose intensity varies across its cross-section, in direct correspondence with the variation of photoelectron yield across the sample surface) is amplified several thousand times by a microchannel electron multiplier plate before striking the phosphor screen. The microchannel plate performs an analogous function to an electron multiplier, or rather, it acts like hundreds of miniature electron multipliers clustered together. The microchannel plate has a large active surface, at which incident electrons striking each point are amplified independently. The amplified electron beam emerging at the opposite end is accelerated by a high voltage before striking the phosphor screen.

The image formed on the screen may be

observed directly, or may be analysed and displayed by an electronic signal processor. The use of such data processing systems allows a great deal of data to be collected and analysed. Since a photoelectron spectromicroscope provides structural *and* chemical information about the sample surface, it can do everything that a photoelectron spectrometer can do, and much more. In the very near future, the chemical analyst/microscopist should be able to routinely select any point on a photoelectron micrograph, obtain the X-ray and VUV photoelectron spectrum of the sample surface at that point, and derive its chemical composition.

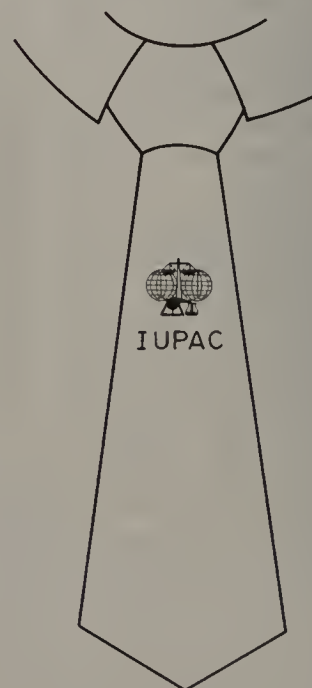
Plans are already well advanced to introduce a commercial version of Dr. Turner's photoelectron microscope. He is presently collaborating with Thor Research Instruments (a company with expertise in superconducting magnets, located about 15 kilometres from Oxford University on Henley Road, Berinsfield) to develop and market a commercial instrument. It is interesting to note that Dr. Turner could become one of the few scientists who has brought a new technique (photoelectron spectroscopy) into existence, and then developed a technique to replace it.

** The one-day meeting on "Microscopy of Solid Surfaces" was held at Imperial College, London on 16 March, 1982. Dr. Turner presented the Liversidge Lecture at the meeting, which was hosted by the Faraday Division of the Royal Society of Chemistry (UK).*

New supply of IUPAC neckties are delivered for sale from IUPAC Secretariat

IUPAC Commission members who attended the 1981 General Assembly may recall seeing a boisterous gathering just outside the IUPAC Secretariat desk in the lobby of one university building. This was *not* a heated discussion about a new definition of atomic weights. Nor was it an impromptu meeting to debate the pros and cons of allowing individual chemists to become Affiliate Members of IUPAC. Rather, it was a group of IUPAC participants trying to buy the last few IUPAC neckties. The initial limited edition was rapidly sold out.

To meet the unsatisfied demand, a fresh supply of IUPAC neckties has recently been delivered to the IUPAC Secretariat in Oxford, and is available exclusively to members and past members of IUPAC bodies and those actively involved with the work of IUPAC. The ties are available in blue and maroon, with the IUPAC logo in gold and white (about 25 mm × 25 mm in size). To order your tie, send a cheque for £4.25 (or US\$12) to the IUPAC Secretariat, 2 - 3 Pound Way, Cowley Centre, Oxford OX4 3YF, UK. Please indicate your colour preference, and whether the other colour may be substituted if your first choice is sold out.



Specialized systems for naming chemicals meet diverse needs of nomenclature users

It has been said that chemical theories tend to be either *too good* (simple and easy-to-use) to be true (accurate), or *too true* to be any good. This might perhaps reflect the biased view of an experimentalist, but it does underscore a fundamental dilemma in chemistry. Simplicity and accuracy are irreconcilable goals; only by sacrificing one for the other can a workable compromise be achieved. This is certainly true for chemical nomenclature, for which no system has yet been developed that provides simple, distinctive and meaningful names for every chemical compound.

The practice of making up a "common" or "trivial" name for each compound, for example, was satisfactory when chemistry was in its infancy, but became unworkable as the number of known compounds expanded rapidly (more than 5.6 million chemical compounds have now been described in the chemical literature). The task of devising a set of rules, so that chemists throughout the world would derive the same name for one substance (or conversely, would derive the same molecular structure from a given name), was undertaken by IUPAC. The functions of revising, updating and extending this nomenclature system is undertaken by three IUPAC Commissions and a joint IUPAC-IUB Commission. Each Commission directs its efforts towards one area of chemistry—inorganic, organic, macromolecular or biochemical compounds—while the Interdivisional Committee on Nomenclature and Symbols ensures that new nomenclature recommendations are consistent with nomenclature recommended by other IUPAC Commissions and international organizations concerned with nomenclature.

The IUPAC system of nomenclature is the one with which most chemists are most familiar. It provides a name that is distinctive and informative for each compound. The name completely describes the chemical structure of the compound, and might even indicate its chemical properties. Structural relationships are easily recognized, since similar compounds almost always have similar names. However, the system becomes unwieldy when applied to very complicated compounds, especially natural products and their derivatives (which are important in many medical and industrial applications). Systematic IUPAC names for these compounds are sometimes virtually impossible to pronounce, and since structurally-similar derivatives have similar names, their names can easily be confused.

Systematic IUPAC nomenclature is geared to the needs of research chemists, who are concerned with the chemical structure of the compounds they synthesize or modify. Other groups (or the same individuals in different situations) have need of nomenclature systems that meet different criteria. They might require names that are simple and distinctive, or that convey information about the compound's biological activity, or that are easily indexed for computer storage or retrieval. A number of chemical nomenclature systems are evolving to meet those needs. This is not to say that IUPAC nomenclature is declining in importance. Most nomenclature experts agree that systematic chemical nomenclature will continue to be used in parallel with "trivial" names and semi-systematic nomenclature, in addition to chemical formulae and computer Registry Numbers. Many chemists will find themselves using several nomenclature systems as they become involved in different aspects of the same project.

An interesting approach for the adoption of simple, distinctive, semi-systematic names for pharmaceutical compounds has been developed by the World Health Organization. It is intended to overcome the serious difficulties which arise when each pharmaceutical manufacturer describes his product with a trademark (that is, a name which that manufacturer has an exclusive right to use). When a chronically-ill person travels abroad, for example, how can he be sure of finding his standard medication if it is sold under an unfamiliar trade name? Confronted with a foreign prescription, the local pharmacist may be unable to provide the medication if he does not recognize the drug name used. This is simply one illustration among many of the need for a single, simple, informative name for each pharmaceutical substance, known the world over and freely available for use by any manufacturer (or anyone else).

Trademarks are unsuitable for this purpose. Only the owner of a trademark has the legal right to use it. A given drug may have many tradenames. The tranquillizer diazepam, for example, is sold under at least 75 trademarks, including Valium. Systematic chemical names could be used in principle (they are universal, and their use is not restricted), but they are too complex and cumbersome. A drug is usually allocated a code number while it is under investigation prior to marketing, but this too is unsuitable since it conveys nothing of the

drug's nature and is difficult to remember or recognize.

In recognition of this need, the World Health Organization began a programme in the 1950's to identify each pharmaceutical substance by a unique, universally-available and unrestricted ("nonproprietary") name. Today, virtually every pharmaceutical compound is assigned an International Nonproprietary Name (INN) by the time it is ready for sale.

Once a request for an INN has been submitted to the World Health Organization, the Director-General forwards it to a WHO Expert Advisory Panel. The panel follows several well-defined principles* in devising a suitable name for the drug. Of primary importance, the INN should be distinctive in sound and spelling. It should not be inconveniently long, and should not be too similar to any existing trademark or other name with which it might be confused. Furthermore, substances that are pharmacologically-related should have names which show their similar chemical structure or activity.

INNs were initially devised by contracting chemical names. This approach has now been abandoned, since the use of prefixes like chlor-, methoxy- and oxy- resulted in names that were too long, sounded too much alike, conveyed little information to physicians, and were clumsy to use. The recent trend has been towards shorter, simpler INNs. Names like "diiodohydroxyquinoline" and "noramidopyrine" would almost certainly not be adopted presently. Although the present emphasis is on simple names, INNs generally *do* convey some information about the biological origin, pharmacological properties or chemical structure of the compound. The name contains a characteristic stem (such as -azepam for tranquillizer compounds with a chemical structure similar to diazepam; -cillin for antibiotics with the same molecular framework as penicillin, or -tizide for diuretics with a chemical structure similar to chlorothiazide). The stem is modified by a group of prefix letters (which allows a distinctive beginning). One-word names are preferred

for acids, and simple salts and esters are named as derivatives, following some general chemical principles. The sodium salt of the antibiotic "oxacillin", for example, is simply named "oxacillin sodium". Other examples are "detajmium bitartrate" and "truxicuriium iodide".

Once the WHO panel has devised a proposed INN, it is published in the *WHO Chronicle* and other publications. If there are no objections to the use of this proposed name (generally on the grounds that it is too similar to an existing trademark), then the name is published as a recommended INN. This procedure is analogous to that followed by the IUPAC Nomenclature Commissions. In fact, the Joint Commission on Biochemical Nomenclature maintains a liaison through the WHO Secretariat and with the Advisory Panel on Nonproprietary Names. The IUPAC Commission has included a number of INNs in their recommendations for nomenclature of Vitamin D derivatives and Retinoids (Vitamin A).

There is a limit, however, how far one can go by using modified INNs to name derivatives of complicated drug molecules. INNs and other "trivial" names for steroid derivatives, for example, do not state the positions or configuration of double bonds or hydroxyl groups. When such information is included (as in IUPAC-recommended systematic steroid names), the names become quite cumbersome, even though the simple name of the parent compound already includes much information on its structure. One encounters, once again, the dilemma of simplicity vs accuracy.

** The WHO criteria for devising International Nonproprietary Names are explained in the article "The selection and protection of international nonproprietary names for pharmaceutical substances" by Agathe Wehrli, published in the WHO Chronicle, Volume 35 (1981), and in the WHO Technical Report (No. 581) "Nonproprietary names for Pharmaceutical Substances".*

Enzymes are the key for rapid, specific chemical analysis

The ability of biological organisms to induce one particular chemical reaction in a specific compound has always been the envy of chemical analysts. Living things produce enzymes, complex protein molecules which can catalyse specific chemical synthesis, transformation and degradation reactions. For many years, chemists have been able to extract these compounds from plant and animal tissues, but the poor stability and high cost of enzymes have limited their usefulness. However, new techniques that bind enzymes within artificial membranes are allowing researchers to incorporate these biological catalysts into ingenious new chemical probes.

These new devices utilize enzymes to induce specific reactions in substrate compounds. The reaction generates a product which can easily be detected—by its light absorption or fluorescence, or by altering the electrical potential of an ion-selective electrode. By merely inserting the enzyme electrode or probe into the sample solution, the concentration of the substrate compound can be measured directly. The analyst can generally determine the concentration of a complex organic molecule within a few minutes. Sometimes, the analysis probe is completely specific—responding only to that particular compound, and no others.

A key feature of all enzyme electrodes and probes is that the enzyme is chemically bound to a macromolecule or a solid surface, or is physically entrapped within the mesh-like structure of a polymer gel. In either case, the enzyme is immobilized on, or in, a thin film. The enzyme does not enter the sample solution; the reaction occurs only when the substrate compound diffuses into the enzyme-containing film from the sample solution.

Immobilization of an enzyme offers several outstanding advantages. Since the enzyme is not washed away with the sample solution, it can be used repeatedly, for hundreds or thousands of chemical analyses. Immobilized enzymes are generally more stable, and have a longer lifetime, than enzymes in solution. The environment within a polymer film can be controlled so that the pH is maintained at the optimal level for enzyme activity and lifetime. Immobilization in a polymer gel protects the enzyme from bacterial spoilage, which is a main factor limiting the lifetime of enzymes in solution. Bacteria which would attack and degrade the enzyme are too large to diffuse through voids in the polymer film. For the same reason, immobilized enzymes are less susceptible to compounds which inhibit their activity. Fur-

thermore, immobilized enzymes are better able to withstand high temperatures (retaining their activity even after exposure to 65°C).

The function of the immobilized enzyme is to bring about a change in concentration of a product or reactant. The analysis probe can then detect light absorption or fluorescence by the reaction product (or reactant), or might contain an ion-selective electrode whose electrical potential varies in direct response to a particular ion.

The development of new ion-selective electrodes has played a particularly important role in expanding the versatility of enzyme analysis probes. Ion-selective electrodes are now available for direct concentration measurements on a wide range of product ions (see feature article in *Chemistry International*, No. 1, 1982). Enzyme electrodes are formed by simply placing an enzyme-impregnated film over an ion-selective electrode.

Measurements with an enzyme probe can be performed by either of two methods. In the rate method, used in many ion-selective electrodes, one measures the *initial rate* of the enzyme-catalysed reaction. Conditions that affect the reaction rate (pH and temperature) must be carefully controlled for accurate, reproducible readings to be obtained. Most enzyme reactions undergo a 10% increase in rate for each 1° rise in temperature. The reaction rate is often limited by diffusion of the substrate to the enzyme-containing film, so a constant stirring speed must also be maintained.

In the steady-state method, the probe measures the *total concentration* of product or unreacted starting material remaining when the reaction reaches equilibrium. In actual practice, one need only wait until the reaction products have accumulated to about 80 - 90% their equilibrium concentrations. Accurate, reproducible results are obtained if measurements are made after a consistent time interval. Use of a large amount of enzyme ensures that the substrate and its reaction products rapidly approach their equilibrium concentrations.

One example of an enzyme electrode is a specific probe for the determination of L-lysine in foodstuffs. The content of this amino acid is deficient in many grains, and the amount of L-lysine therefore determines the nutritional value of its protein. For this reason, grains are routinely screened for their content of L-lysine, and a simple rapid method for analysis of L-lysine is therefore very useful.

A totally specific L-lysine enzyme electrode was developed in 1978 by Professor George

Guilbault and co-worker W. Claude White (at the University of New Orleans). It utilizes an L-lysine decarboxylase enzyme (which can be isolated from *E. coli* bacteria, and is commercially available). The enzyme is entrapped within a film of proteinaceous gel covering the sensor of a CO₂-selective electrode. When the electrode is inserted into sample solution containing L-lysine, the amino acid undergoes a decarboxylation reaction, liberating carbon dioxide. The gaseous product diffuses through the underlying gas-permeable teflon membrane, where it causes a change in pH of an electrolyte solution. The change in solution pH is detected by a specially-constructed pH electrode. The electrode potential responds only to changes in L-lysine concentration. The enzyme has no effect on any other amino acid (or even on its optical isomer, D-lysine). The response of the L-lysine electrode is linear over a hundredfold concentration range, from about 10⁻⁴ to 3 × 10⁻² M. The only reagent needed for the analysis, once the food sample has been hydrolyzed to its constituent amino acids, is a pH buffer.

The relatively long response time of the L-lysine electrode is its only significant limitation. In addition to the time required for the CO₂-sensitive electrode to respond, an equilibrium must be established between the production of carbon dioxide (which depends on diffusion of L-lysine into the gel), and its escape from the immobilized enzyme layer. Once an equilibrium CO₂ level is attained, the electrode potential remains quite stable. After the measurement is completed, carbon dioxide must diffuse out of the enzyme layer in preparation for the next measurement. The time for the electrode to return to its "baseline" potential is even longer than that required

for the CO₂ concentration to reach an equilibrium level during a measurement.

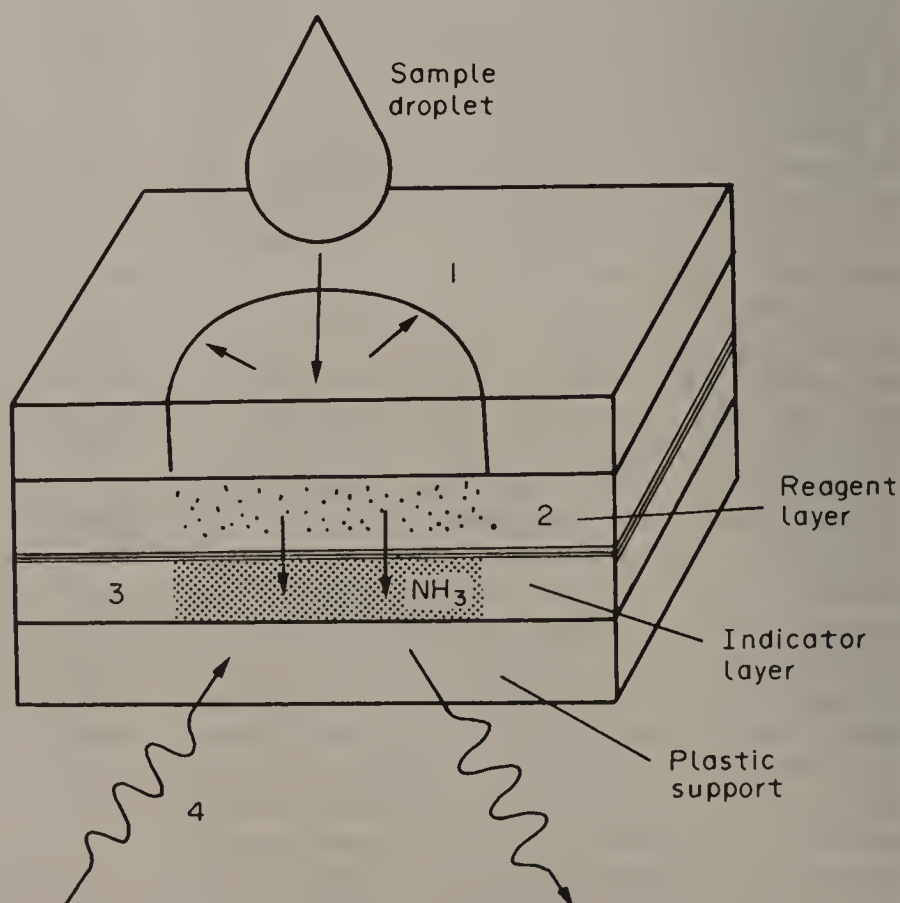
The total time needed for each analysis, from the start of one assay until the electrode is ready for the next sample, varies from 10 to 30 min (depending on the concentration of L-lysine). Compared to other electrode measurements, this is somewhat long, but would probably not be considered a severe limitation in light of its simplicity, total specificity and low cost.

Incorporating immobilized enzymes into re-usable analysis probes is one approach for simple, low-cost chemical analysis. Another is the use of enzymes in miniature disposable slides. These consist of several layers, assembled on a thin sheet of plastic using recently-developed thin-film technology. The reaction layer, containing the enzyme and other reagents, is usually about one cm² in area and has a thickness of only 10⁻² mm. Consequently, each slide contains only miniscule amounts of enzymes and reagents. Very small samples (usually, a 10 microlitre droplet) are required.

The enzyme and acid - base buffer are held within a polymer gel (gelatin or agarose). As sample solution permeates into the reaction layer, the enzyme catalyses the decomposition or hydrolysis of the substrate. One breakdown product undergoes a further reaction, generating a coloured complex. If the product is acidic, for example, it might protonate a pH indicator dye. Alternately, the reaction product might oxidize or reduce a dye precursor. In any case, the concentration of substrate in the sample is determined by measuring light absorption by the complex.

To obtain a reading of the substrate concentration, the slide is illuminated from underneath with a monitoring light beam (of a wavelength absorbed by the dye or coloured

All enzymes and reagents for analysing the urea concentration of one sample can be contained in a disposable slide. The sample solution is initially applied to the top "spreading layer" of the slide. The solution saturates the porous material and spreads outwards until the entire sample droplet has soaked in (1). The sample then diffuses downward into the reagent layer (2), where the enzyme hydrolyses urea to ammonia and carbon dioxide. Ammonia gas generated by the reaction can diffuse through a semipermeable membrane (3) into an indicator layer. The resulting increase in pH causes a colour change in an acid-base indicator. The response is specific for urea, whose concentration is determined by measuring absorption of a light beam passing through the indicator layer.



complex). The light beam passes through the transparent plastic base and the reagent layer, and is reflected back through the slide by a top "spreading layer" consisting of porous polymer containing a white pigment (such as TiO_2).

As well as reflecting the incident light, this top layer spreads the applied sample droplet. Although it is much thicker than the underlying reagent layer, the depth of the "spreading layer" is only about one-tenth the diameter of the sample droplet. As the sample solution rapidly saturates the porous polymer, it permeates outwards across the spreading layer. When the entire droplet has soaked in, the porous covering contains a constant volume of sample solution *per unit area*. The substrate then diffuses downwards into the reagent layer. The intensity of colour produced by the enzyme reaction depends only on the *concentration* of the substrate, and is nearly independent of the volume of the sample droplet.

All reagents for the analysis are contained within the disposable slide. The multilayer element contains all enzymes and reagents and, if necessary, effects a separation of the reaction products. The slide serves as both a reaction vessel and spectrometer cell.

A slide for the analysis of glucose was one of the first to be introduced (in 1978). It provides a specific test for this clinically-important sugar, and test results are largely unaffected by the presence of fructose, galactose and other sugars with a very similar molecular structure. The slide utilizes a glucose oxidase enzyme to catalyse the oxidation of glucose. The reaction is accompanied by the liberation of hydrogen peroxide. This induces a second reaction in the reagent layer, which produces a coloured compound.

Another slide system was developed for the analysis of urea. This slide is generally used to measure the content of urea in blood serum, a test result which is important for the diagnosis of kidney malfunction. The slide's reagent layer contains a urease enzyme, which catalyses the hydrolysis of urea to ammonia and carbon dioxide. The carbon dioxide is converted to carbonate ions, since the pH is maintained slightly alkaline by an acid - base buffer, and remains in the reagent layer. Ammonia gas produced by the reaction is, however, able to diffuse through a semi-permeable membrane of cellulose acetate butyrate. This allows the ammonia to diffuse to an underlying indicator layer, which contains a pH-sensitive indicator

dye. The semipermeable membrane blocks the diffusion of hydroxyl ions, so the change in colour of the indicator is a specific response to ammonia. Diffusion of ammonia through the membrane is slow, and this limits the rate at which the coloured dye is formed. However, the analyst need not wait for the reaction to reach equilibrium; a reliable reading of urea concentration is obtained by measuring the light absorption 7 min after a droplet of a sample has been applied to the slide.

The same configuration of semipermeable membrane and indicator layer is also utilized in other slide systems to monitor the evolution of ammonia. This indicator system is also used, for example, in the slide for analysis of creatinine (a compound produced in muscle tissue). The reagent layer contains a creatinine iminohydrolase enzyme, which hydrolyses the imine group from the compound's heterocyclic ring and generates ammonia. Once again, the ammonia diffuses through a cellulose acetate butyrate membrane and induces a colour change in a Bromophenol Blue indicator (reaction with ammonia causes the indicator to absorb at a wavelength which can easily be distinguished from light absorption of the dye in its original form).

Three enzymes are utilized in a slide recently developed for the determination of total serum cholesterol. Cholesterol esters are initially hydrolyzed to free cholesterol, which then acts as a substrate for cholesterol oxidase. This second enzyme-induced reaction generates hydrogen peroxide. In the presence of a peroxidase enzyme, the hydrogen peroxide oxidizes a triarylimidazole dye precursor to produce a strongly-coloured compound. All three enzymes, the dye precursor and buffer are contained in one reagent layer.

Research and development of disposable enzyme-containing slides has been carried out primarily at Kodak Research Laboratories in the USA (using similar fabrication techniques as is used to manufacture photographic film). So far, their slide systems have been intended solely for the analysis of compounds which are of clinical or medical importance. However, it is reasonable to expect that Kodak will diversify their slide technology to other types of chemical analysis. It is difficult to make an accurate projection about the types of compounds which might best be suited for slide analysis. With the enzymes now available, there is a wide range of potential applications.

Progress towards solid-state electrochemical propulsion batteries

The recent development of novel materials with extraordinary electrochemical properties has created exciting opportunities for future breakthroughs in electrochemical research. These advances have opened the way for development of entirely new types of battery systems. Experimental batteries have been constructed, for example, with electrodes and electrolytes composed entirely of solid inorganic salts. Other researchers have made rechargeable batteries from ion-conducting plastics. It is reasonable to expect that all-solid-state batteries will be introduced, composed entirely of non-conventional materials. The absence of liquid electrolyte will reduce or eliminate self-discharge reactions that limit the "shelf life" of the battery. Furthermore, the battery's operating temperature range will not be limited by the freezing or boiling point of a liquid electrolyte, allowing its use in extremely harsh environmental conditions (such as in outer space, for example). Based on preliminary experimental results, it is reasonable to expect that non-conventional battery systems might soon be developed that are completely free of corrosion and leakage problems, might be charged and discharged many thousands of times without a decline in performance, have far greater energy storage capacity than conventional batteries, and retain their charge for almost unlimited periods.

Introduction of radically new battery systems could be the breakthrough necessary for electric vehicles to become a major transportation system. By utilizing mouldable polymer electrodes and electrolytes, battery designers may be able to fabricate batteries in any desired shape—perhaps forming the structural framework of an automobile body. Alternatively, lightweight batteries could be incorporated into photovoltaic solar panels, so that these units can generate and store electricity from sunlight.

In addition to their practical applications, these developments will almost certainly revolutionize the way chemists view electrochemistry. Well-established notions will have to be rejected. Electrochemistry will no longer be restricted to processes involving metals, solutions and molten salts. Researchers have already demonstrated that solid-state batteries can be made without any metals or metal ions. What are presently regarded as exotic phenomena—electron conduction in plastics, ion conduction in inorganic crystals, and electrodeposition of ions within polymers or crystalline salts—may acquire such practical and fundamental importance as to form the basis on which electrochemistry is taught to 1st year chemistry students.

All battery systems utilize the energy evolved by a chemical reaction to produce electric power. Conventional batteries utilize metal electrodes and conductors. The metal anode is oxidized and dissolved (forming metal ions, which enter the electrolyte solution) as it liberates electrons. Electrons flow from this electrode—through an electrical circuit—to the cathode, where reduction occurs. The cathode is usually made from a material that is easily reduced. Some batteries employ a metal oxide cathode (such as PbO_2 in the lead - acid battery), while others contain a highly electropositive element (such as liquid bromine). Alternately, the cathode may be an inert conductor (like graphite), acting as a conductive surface on which ions in the electrolyte are electrocoated or electroreduced.

Many different chemical reactions are used in presently-available systems. A common and fundamental feature of these batteries is that the *energy-producing reactions occur at the interface* between the electrodes (which are usually metal or solid metal oxides) and the liquid electrolyte (which are usually aqueous solutions, but may be molten salts). At any one instant, oxidation/reduction reactions occur only at the two surfaces where the electrodes and electrolyte are in contact. Of course, the electrodes and electrolyte often have substantial thickness and mass to provide a reservoir of chemical reagents. Furthermore, it is important to realize that the metal - solution interface may not be limited to the electrode's visible outer surface. Electrodes are often fabricated to have a porous structure, so that the metal - solution interface has a large surface area extending well below its outer surface.

In contrast, many of the new battery systems being developed employ *insertion electrodes*. These are inorganic salts or organic polymers whose structure contains channels large enough to allow the diffusion of ions, while the crystalline framework allows electron conduction. One such compound is TiS_2 , which conducts lithium ions and electrons. This compound is presently being investigated as an electrode for solid-state batteries by Dr. Brian Steele (at Imperial College's Unit for Solid-State Ionics, in London) and other battery researchers throughout the world.

The structure of TiS_2 is formed by titanium and sulfur atoms bonded into flat sheets, held 0.57 nm apart by weak Van der Waals bonds. Because of their small size, lithium ions can diffuse between the layers of the TiS_2 framework. Furthermore, the bonding of titanium and sulfur atoms gives rise to electron orbitals extending throughout the TiS_2 structure. These orbitals have many vacancies to accommodate additional electrons, and are responsible for the electrical conductivity of TiS_2 . Thus, TiS_2 remains electrically neutral by gaining lithium ions *and* electrons. Incorporation of lithium ion - electron pairs does not alter the crystalline structure of TiS_2 (although it does cause the spacing between TiS_2 layers to increase slightly). The lithium - TiS_2 complex is non-stoichiometric—that is, the amount of lithium can vary continuously. A TiS_2 electrode can gain lithium ions until most of the available space in its atomic-size channels is filled. This occurs when the structure contains about as many lithium ions as there are

titanium atoms in the structural framework. Some additional lithium ions can then be accommodated, but the electrode would generate a much lower oxidation potential.

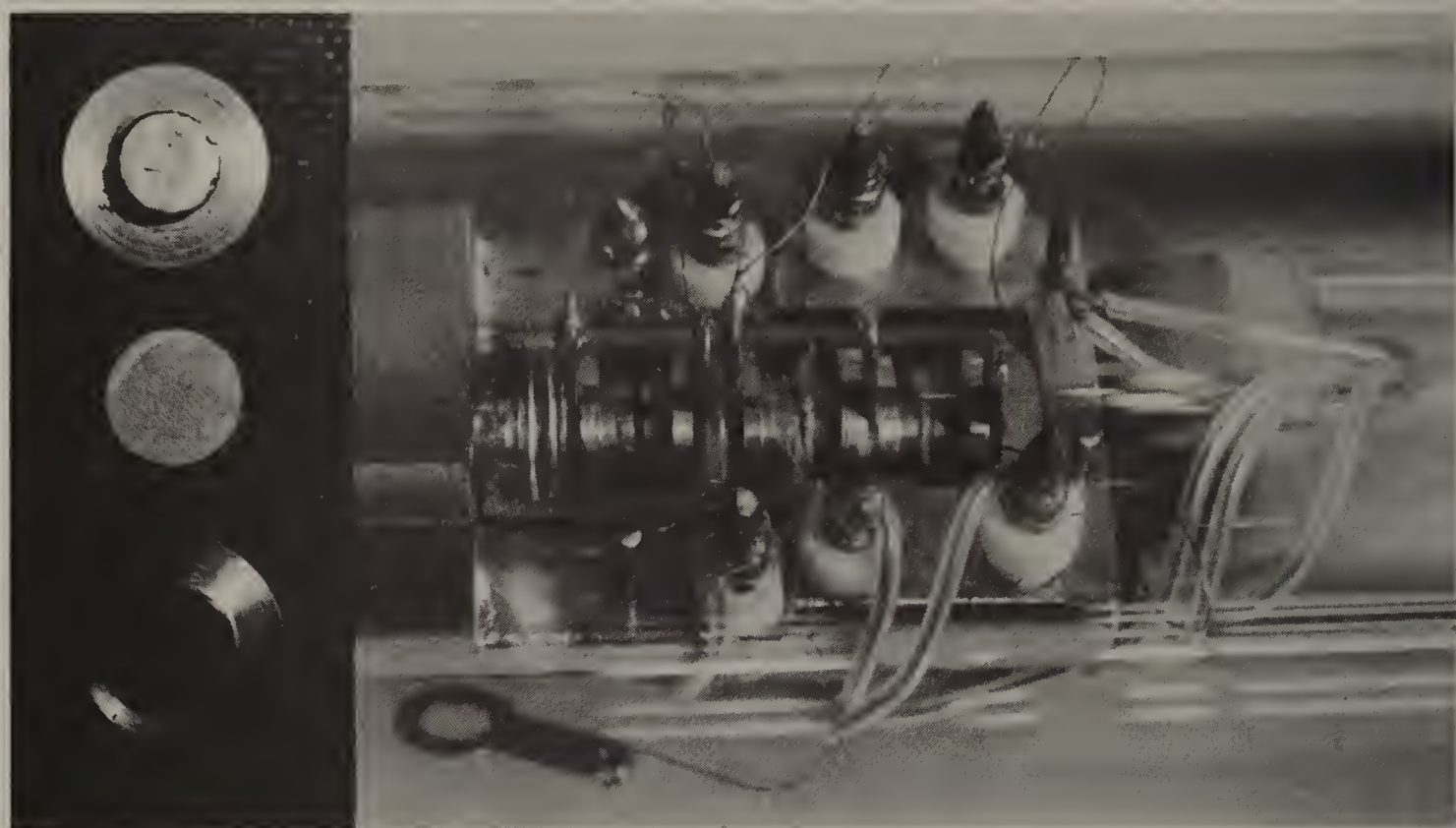
One experimental cell made by Dr. Steele's group employs a lithium metal anode and TiS_2 cathode separated by a thin film of lithium-conducting polymer (Polymeric Ethylene Oxide, PEO). The energy-storage capacity that could, theoretically, be achieved with this all-solid-state electrochemical cell is 480 watt-hours/kilogram. This far exceeds the energy storage capacity of lead - acid batteries (theoretically 170 W-h/kg, but only 30 W-h/kg is attained in practical batteries) and compares well with the potential energy storage capacity of other advanced battery systems presently being developed (such as the sodium - sulfur or zinc - air batteries).

Oxidation of lithium at the anode of the experimental battery occurs in much the same way as in a conventional battery. As electrons leave the metal electrode, lithium ions diffuse from the metal surface into the PEO ion-conductive layer. Upon reaching the cathode, the lithium ions diffuse into channels in the TiS_2 framework. Simultaneously, electrons flow through the external circuit into the cathode, where they become localized within bonding orbitals in the TiS_2 framework. The "host" lithium ions in the TiS_2 cathode become bound to the negatively-charged framework.

It is important to note that, although the Li_xTiS_2 complex is often termed a "solid solution", it does not contain reduced lithium ions. The electrode reaction is *not* simply the reduction of lithium ions to lithium metal. If it was, then the cathode reaction would merely be the reverse of lithium oxidation at the anode, and the cell could generate little or no electrical energy. Clearly, electrons do not recombine with lithium ions in the Li_xTiS_2 complex, but are held within orbitals of the TiS_2 framework. However, there must be some interaction between the lithium ions and electrons in the TiS_2 framework. Otherwise, the oxidation potential of the TiS_2 electrode would fall dramatically as soon as a few lithium ions had permeated into the structure, and would rapidly approach the potential of the lithium anode. We might imagine that, although lithium ions and electrons are held apart in the Li_xTiS_2 structure, there is a substantial electrostatic attraction.

Regardless of the exact nature of the chemical interactions in Li_xTiS_2 , the important point is that insertion of lithium ions is almost completely reversible. The potential generated by a lithium-charged TiS_2 electrode and its Li^+ -holding capacity change relatively little after the cell has been charged and discharged 1000 times. After similar use, conventional batteries often exhibit serious deterioration in performance or complete failure.

Diffusion of lithium ions into the TiS_2 structure causes the material to expand. A mole of TiS_2 undergoes a 9% increase in volume when it incorporates one mole of lithium ions and electrons. In order to avoid fracture of the electrode during repeated charging and discharging, the battery must contain some elastic material to relieve mechanical stress. One advantage of using polymeric ethylene



One experimental all-solid-state battery is made by stacking lithium pellets (anodes), PEO polymer electrolyte and V_6O_{13} insertion compound (cathode). Individual electrodes are also shown (mounted on their stainless steel holders) at about $1\frac{1}{2}$ times their actual size. An unusual feature of the experimental apparatus used by Dr. Steele's group at Imperial College is that the battery can be viewed inside its double-layered glass enclosure, which serves as a heat-insulating jacket. The enclosure is maintained at constant temperature (usually about 120°C) by electric heating of a transparent semi-conducting coating on the glass surface.

oxide electrolyte is that it can provide the necessary elasticity. PEO is not only contained in the thin electrolyte layer, but is mixed with TiS_2 and pressed into the cathode material. The presence of PEO particles interspersed with TiS_2 increases the effective electrode/electrolyte surface area—in exactly the same way that porous electrodes enable conventional batteries to provide higher power output.

Polymeric ethylene oxide has low lithium ion conductivity at room temperature, so experimental batteries with this solid electrolyte operate at about 100°C . Even at this temperature, lithium ion conductivity of PEO is only about one-hundredth the electrical conductivity of a typical aqueous electrolyte. However, the solid ion-conducting electrolyte does not serve as a storage medium for chemical reagents, and consequently, only a very thin layer of electrolyte need be used—even in a large battery. PEO can easily be fabricated into thin films, whose conductivity is comparable with solution electrolytes in conventional batteries.

Battery operation at slightly elevated temperature is not necessarily a disadvantage, Dr. Steele points out. The temperatures required for ion conduction in PEO electrolyte are well below those required for other advanced high-temperature battery systems (like the sodium - sulfur battery), and would not limit the choice of materials used to construct and insulate the battery. In fact, for high-power applications, operation at above-ambient temperature could greatly facilitate the dissipation of waste heat. Nonetheless, battery researchers are investigating other solid electrolytes which provide adequate lithium ion conductivity at room temperature. A number of solid-electrolytes which function at room temperature are

known, and these are already used to manufacture special-purpose electronic devices (see "Electrochemical devices take a place alongside the silicon chip" in *Chemistry International*, 1981, No.4). Among the most promising candidates for solid room-temperature ion-conductors is a lithium sulfide glass, $Li_2S - P_2S_5 - LiI$.

Materials to be used as solid electrolytes must possess the same structural features as insertion compounds used for electrodes. The material must contain channels through which a host ion can diffuse rapidly by hopping into nearby vacant sites. But unlike insertion compounds, solid electrolytes do *not* conduct electrons—and that is the fundamental difference allowing the two types of materials to perform entirely separate and complementary functions.

In the same way as new solid electrolytes are being discovered and synthesized, many new insertion compounds have been identified as promising electrode materials. The availability of novel cathode materials is by no means limited to TiS_2 . Many other compounds are found to incorporate lithium ions and electrons. One extraordinary example is amorphous MoS_3 (prepared by decomposition of ammonium thiomolybdate). One mole of this material can reversibly incorporate up to 3.8 moles of lithium. The theoretical energy storage capacity of a $Li - MoS_3$ cell is 1000 W-h/kg—very near the limit of energy storage capacity that could be achieved with any battery system now under development.

Some insertion compounds, such as CoO_2 and NiO_2 , have a powerful propensity to gain lithium ions and electrons, and generate a very high oxidation potential. These compounds might ultimately be exploited in lithium cells producing high voltage (as

much as 4.5 volts, compared to about 2 volts for a lithium - TiS_2 cell), and provide a specific energy storage capacity of about 1000 W-h/kg. However, the high oxidation potential generated by these compounds degrades presently-available solid electrolytes. The practical use of such electrode materials therefore depends on the development of new oxidation-resistant solid electrolytes.

Among the insertion compounds discovered so far, FeS_2 , V_6O_{13} and $(\text{V}_{0.75}\text{Mo}_{0.25})_2\text{O}_5$ are felt to be the most promising electrode materials for application in the near future. In particular, V_6O_{13} undergoes a very small change in volume when it incorporates lithium ions. It generates a slightly higher oxidation potential than TiS_2 , and provides a theoretical energy storage capacity of 800 W-h/kg. The properties of V_6O_{13} have been extensively studied by researchers at Bell Laboratories (USA).

It appears that presently-available insertion compounds could meet all requirements for cathode materials in solid-state batteries. The best prospects for further advances lie in the development of new insertion compounds with a very low oxidation potential to replace the lithium anode. One of the main limitations of lithium, and some other conventional electrode materials, is its tendency to form dendrites at the surface of the electrode. Once the electrode surface begins to become pitted or uneven, the protruding metal receives a higher current density than the surrounding electrode surface. Lithium is electrodeposited more rapidly on these areas (during recharging of the battery), causing the unevenness of the surface to become progressively more pronounced.

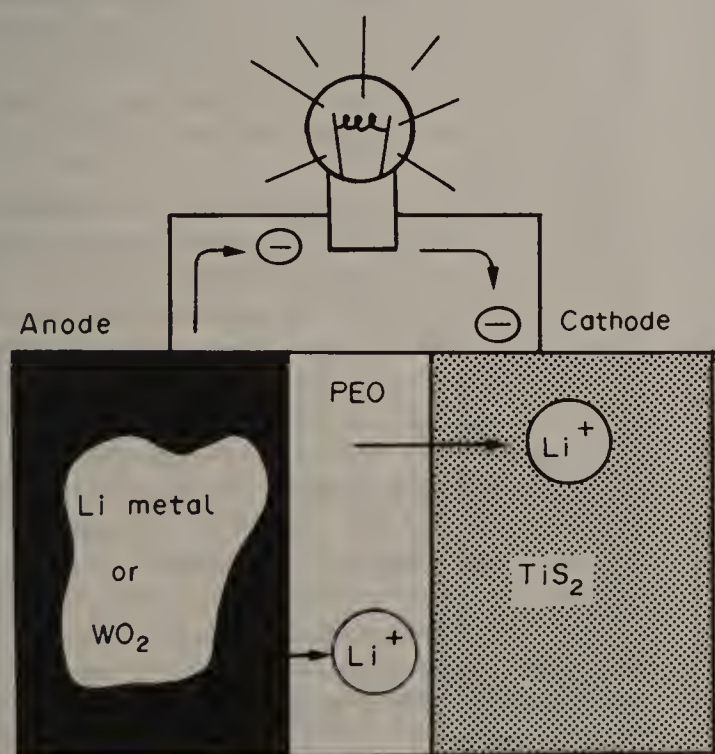
Dendrite formation is not a serious problem with the low current densities (about 1 mA/cm²) and 120°C temperature at which experimental Li - PEO - TiS_2 batteries are operated. However, for applications such as vehicle propulsion, batteries

must deliver high power and be rapidly recharged. To meet these requirements, it may be necessary to replace the lithium electrode with an insertion compound of low oxidation potential. WO_2 is one candidate material, although a WO_2 - TiS_2 cell would generate a voltage of only about 1.2 volts. The WO_2 anode would initially be charged with lithium ions (and electrons). When the battery is generating electrical power, lithium ions would diffuse through the solid electrolyte into the TiS_2 cathode.

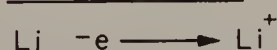
There are, of course, many battery applications which do not require high current densities which could be met with existing materials and technology. Solid-state batteries are, in fact, already widely used to power cardiac pacemakers and other surgically-implanted devices. These devices require extremely low power, but must operate continuously for periods up to 15 years, and possibly longer. Solid-state batteries are uniquely suited for this application and have achieved stunning success in this area. More than 500 000 solid-state pacemaker batteries have been surgically implanted. No doubt, there are many other applications where solid-state batteries could drive low-power electronic control circuits. With such applications in mind, Hitachi Central Research Laboratory (in Japan) announced last year that they had developed a miniature all-solid-state battery.

The most common type of pacemaker battery utilizes a lithium anode, lithium iodide ion-conductor, and a cathode composed of an iodine-(poly-2-vinylpyridine) complex. A striking feature of this battery is that it employs an inorganic ion conductor and an electrically-conductive polymer.

The development of conductive polymers, now an area of intense research activity, could provide the materials needed for a practical high-power battery. Simple macromolecular compounds such as



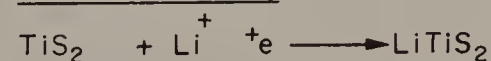
Anode reaction



or

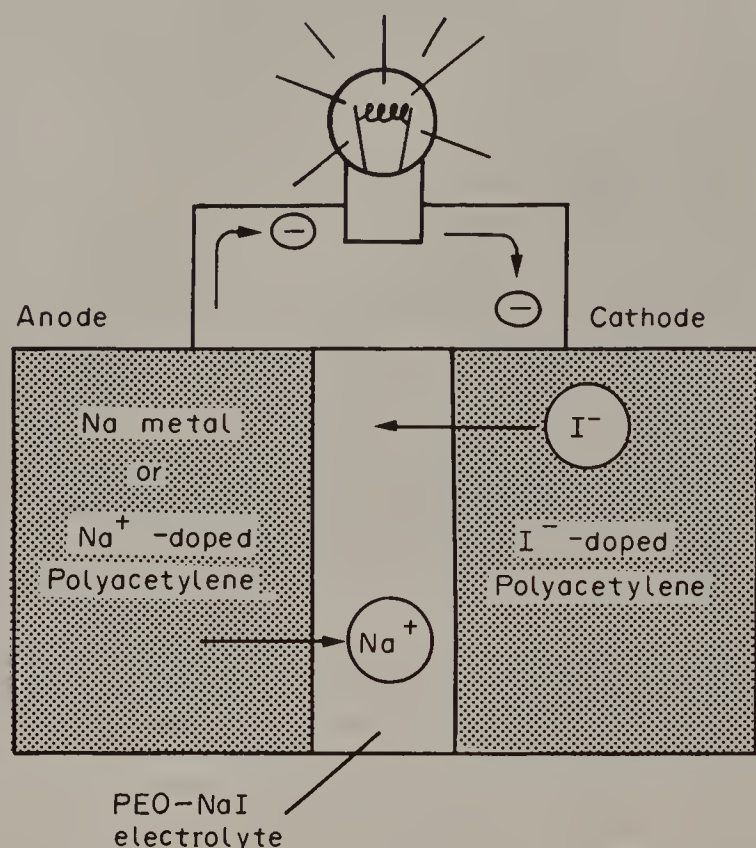


Cathode reaction

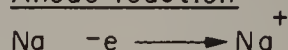


Operation of an all-solid-state battery with insertion electrodes is conceptualized here. The battery anode might be constructed of either lithium metal, or an insertion compound like WO_2 that has been charged with lithium ions and electrons. When the battery is connected to an external circuit, electrons flow from the anode to the cathode. Simultaneously, lithium ions diffuse from the anode, through the ion-conducting PEO solid electrolyte and are (reversibly) bound within the negatively-charged TiS_2 framework.

Electrochemical reactions occurring in doped polymer electrodes are exactly analogous to those occurring in insertion compounds. The anode may be made of sodium metal, or may be composed of polyacetylene which has been doped with sodium ions and electrons (represented here simply as $\text{Na}_x(\text{CH})$). When electrons flow through the external circuit, sodium ions diffuse from the anode into the solid PEO - NaI ion-conductor. Meanwhile, electron flow into the I^- -doped polyacetylene cathode causes iodide ions to diffuse from this electrode, and to collect in the PEO - NaI solid electrolyte.



Anode reaction



or



Cathode reaction



where x can have any value up to about 0.06

Use of doped polyacetylene electrodes allowed researcher C. K. Chiang (at the US National Bureau of Standards) to make rechargeable solid-state batteries composed entirely of polymeric material. His experimental electrochemical cells operate at slightly elevated temperature (85°C), and can generate voltages as high as 3.5 volts.

polyacetylene and polyphenylene have been found to function in much the same way as inorganic insertion compounds. These plastics are electrical insulators in a pure state, but acquire relatively high conductivity when they are chemically or electrochemically "doped" with ions such as Li^+ , Na^+ or $(n\text{-butyl})_4\text{N}^+$, and with electrons.

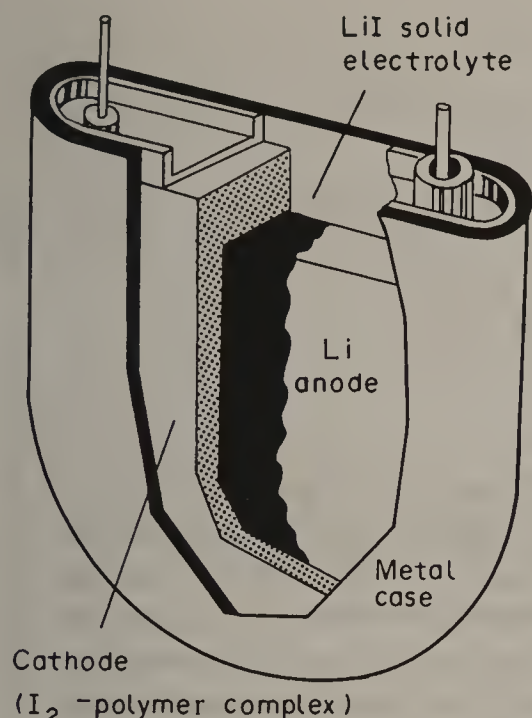
The doping of polymers is similar to the doping of semiconductors used to make transistors and integrated circuits, although polyacetylene and polyphenylene can accommodate dopant concentrations about a million times higher. The dopant ions evidently diffuse through empty channels between polymer fibrils. These channels account for two-thirds the volume of the material.

Doping polyacetylene or polyphenylene does not only impart *ionic conductivity* (due to migration of the dopant ions in an electric field), but also imparts *electron conductivity*. For each positive dopant ion which permeates into the polymer structure, an electron enters an empty molecular orbital extending along the polymer chain. It is the gain (or loss) of electrons during the doping process that is responsible for the material's electrical conductivity. In fact, the researchers who discovered the unique properties of doped polyacetylene (chemist Alan MacDiarmid, physicist Alan Heeger and graduate student Paul Nigro at the University of Pennsylvania, USA) assert that the dopant ion is necessary only to preserve electrical neutrality. The Li^+ , Na^+

or $(n\text{-butyl})_4\text{N}^+$ is not itself oxidized or reduced. Once again, it is clear that there must be some electrostatic attraction between a positive dopant ion and the negatively-charged polymer chain. However, whether this interaction is regarded as a physical or chemical process would depend simply on one's point of view.

Each mole of polyacetylene can be "doped" with as much as 0.1 mole of electrons and Li^+ (or other electron deficient "*n*-type" dopant ions). Alternately, one could impregnate the material with about the same amount of "*p*-type" dopant like I^- or ClO_4^- , and withdraw electrons from completely full molecular orbitals of the polymer (creating mobile vacancies, or "holes"). Although the maximum doping level is substantially less than the content of mobile ions accommodated by inorganic compounds, the polyacetylene matrix is very light. Dopant ions can therefore comprise a substantial fraction of the weight of the doped polymer (by contrast, insertion compounds are composed of heavy metal oxides). The same situation applies to the electrical conductivity of doped polymers. A doped polyacetylene film has about one-tenth the electrical conductivity of a layer of mercury metal of the same thickness and area, but the two materials have about the same *conductivity per unit weight*.

A very simple electrochemical cell with a polymer electrode can be made using lithium metal as anode, a strip of polyacetylene as cathode, and LiClO_4 in



Because solid-state batteries can store electrochemical energy for a very long time, they are used extensively to power cardiac pacemakers. These surgically-implanted devices provide electrical impulses to keep the recipient's heart beating. More than 500 000 pacemakers have now been implanted.

The most common type of pacemaker battery, whose construction is depicted in this cutaway view, is the lithium/LiI/I₂ (poly-2-vinylpyridine) cell. An unusual feature of this battery is that the LiI electrolyte is produced by the discharge reaction of the battery. The LiI layer grows thicker as lithium and iodine are reacted to generate electrical power. Consequently, even if a crack develops in the electrolyte (due to mechanical stress), a fresh layer of LiI would soon form, and operation of the battery would not be affected.

Low ionic conductivity of the LiI electrolyte limits the output current of the cell, although this is not a problem for cardiac pacemakers. These devices draw only a tiny "trickle" of electrical current, although they must operate continuously for periods up to 15 years. Despite the small size (less than 10 cm³ volume) of a solid-state lithium battery, it provides sufficient energy storage capacity (about 7.5 watt-hours) to keep the implanted pacemaker operating for many years.

tetrahydrofuran solution as a liquid electrolyte. When connected to an external circuit, the lithium metal anode is oxidized spontaneously and the polyacetylene cathode becomes doped with lithium ions and electrons.

Polyacetylene can also serve as an anode after it is doped by lithium ions and electrons. For a cathode, one can use polyacetylene doped with, say, ClO₄⁻ ions. As the battery generates electrical power, dopant ions diffuse from both electrodes into the electrolyte. When the battery is later recharged, the polyacetylene electrodes are again doped with their respective ions. The doping process appears to be completely reversible, with no observable degradation after a number of complete charge/discharge cycles.

It is interesting to note that polyacetylene batteries can be constructed without using any metal or metal ions whatsoever. One could use, for example, tetrabutylammonium and perchlorate as dopant ions, and make a metal-free battery with a high energy storage capacity and power output.

Most research with polyacetylene and polyphenylene electrodes has utilized a liquid electrolyte. The main problem barring immediate commercial application of these batteries is the lack of a suitable electrolyte solvent which can tolerate the oxidizing and reducing environments arising at the electrodes. One way to overcome this obstacle might be to use a solid ion-conducting electrolyte and, in fact, such batteries have very recently been described by Dr. C. K. Chiang (at the Polymer Science and Standards Division, US National Bureau of Standards). He was able to construct an all-polymer solid-state battery by using polyacetylene electrodes doped with sodium and iodide ions, and a PEO - NaI complex as an ion-conducting electrolyte. This cell produced a voltage of 3.5 V, which compares very favourably with other advanced battery systems. However, in

Dr. Chiang's preliminary experiments, his all-polymer battery could deliver only modest discharge currents. The estimated maximum power output (10 - 20 W/kg) was significantly less than the power density provided by conventional lead - acid automobile batteries. The power output of these cells was apparently limited by resistance to ion flow between the polymer electrodes and solid electrolyte.

It is impossible to predict which type of solid-state battery systems might find the widest application: those containing electrodes and electrolytes composed of inorganic insertion compounds, or those made of conductive polymers. Various types of hybrid cells can also be envisioned, using insertion compounds or polymer electrodes in conjunction with liquid electrolytes. Such batteries are already being manufactured (Exxon Research & Engineering Company presently make small batteries containing a lithium anode, TiS₂ cathode, and a liquid electrolyte composed of LiClO₄ in an organic solvent). Perhaps the most significant breakthrough will be achieved by amalgamating the two new electrochemical technologies, and utilizing both inorganic and polymer ion-conductors and electrodes. These two research areas have evolved largely independently, and are still being investigated by separate research groups. Technology from both areas has been successfully tapped for the development of cardiac pacemaker batteries. One might envision the development of new batteries incorporating both inorganic and polymer electrodes. It might contain, for example, a Li⁺-doped polyacetylene anode, a solid ion-conducting electrolyte, and a TiS₂ Li⁺-insertion cathode. This, of course, is merely conjective. What *can* be stated with reasonable confidence is that by the next decade electrochemical batteries and electrochemistry will be very different from what they are today.

Serendipity: the raw material for scientific discovery

Scientific research is usually portrayed as a deliberate and systematic search for new knowledge, but it appears that most major scientific discoveries have sprouted from a chance meeting or observation. The contribution of unforeseen fortuitous events is probably often underestimated. This is not to suggest that success in a researcher's career lies entirely in the hands of fate—but rather, that it is tied to his ability to recognize opportunities arising from unforeseen events. Scientists, like everyone else, seem to control their lives indirectly: we do not plan our future; we choose a course that influences the events we experience and the people we meet.

An excellent example of how chance events can contribute to chemical research is provided by the experiences of Dr. James Lovelock. He discovered the phenomenon of electron capture in gases when it interfered with his measurements of air motion. His subsequent invention of the electron capture chromatography detector stemmed from discussion with the research group in the adjacent laboratory, who—by chance—were seeking a more sensitive detector for their chromatographic studies of cell membranes. Twelve years later, while Dr. Lovelock was using his extremely sensitive electron capture detector to investigate a local smog condition, he observed a constant background concentration of fluorocarbons—the first evidence that these compounds were accumulating in the atmosphere.

Dr. Lovelock's experiences were described in the article "The electron capture detector—a personal odyssey", published in the September 1981 issue of *CHEMTECH**, and are presented here in abridged form.

**The article has also been published as the introductory chapter of the book "Electron Capture—Theory and Practice in Chromatography". It is adapted here with permission of Dr. Lovelock and of the American Chemical Society.*

It all began in 1948 when I was working for the British Medical Research Council on the problem of the common cold. In those days, precious little was known about the science of this subject. The man in the street knew all that there was to know about the common cold. To him it was quite simple: you caught colds in the winter by getting cold. Now the Medical Research Council was a government institution and therefore not entirely unaffected by public opinion and political pressure. We thought it might be wise, therefore, to consider the possibility that colds were in fact caught through getting cold. My job was to measure the extent of chilling in different indoor climates, so that it could be compared with data on the frequency of colds. The three factors important in chilling are temperature, humidity, and air movement. The first two are easy to measure, but the

air movements in a closed room—draughts, as the English call them—were so slight as to be undetectable by the simple anemometers then available.

In those days, it was customary to build rather than to buy instruments. Indeed, scientists were expected to invent and, in such circumstances I soon found myself with two novel devices to measure air motion. The first was an ultrasonic device that exploited the change in wavelength of sound due to air motion. It worked well, but was still too insensitive to detect the 0.5 cm/sec air motion we needed to measure. The second method I tried was an ion-drift anemometer. Positive ions move in air at a speed of 1 cm/s in a field of 1 V/cm. The slow drift of these ions was easily perturbed by winds of the speed we needed to measure. It was great fun to make such an anemometer and to find that it worked even better

than expected.

When I say make, I mean it literally. Everything from electronic equipment to the sensing head had to be made by hand. Even the radioactive source needed to ionize the air was made by scraping the dial paint from gauges taken from the instrument panel of World War II military aircraft. These provided a rich harvest of radium or mesothorium. I made the sources by ashing this paint, then resuspending the ash in a thin lacquer, which was painted onto the anemometer ion source. The ion-drift anemometer worked well. The only snag was that its response was perturbed by cigarette smoke; it was as sensitive to this as is a reformed smoker. To discover the source of this drawback, I exposed it to a number of different gases and smokes and found that, in addition to smoke, halocarbon gases disturbed its function. We did not at that time need a device to detect low levels of chlorofluorocarbons and so the electron capture detector was in a sense prematurely invented.

laboration was established that not only answered the fatty acid problem but also led to the development of a range of sensitive ionization detectors, which Martin knew were needed to exploit the full potentialities of gas chromatography.

The first ionization detector I made was modelled on Boer's design of the ionization cross-section detector. It was in effect a gas thickness gauge. The denser the gas, the greater the number of ions, and consequently the larger the flow of current.

This detector works best with light carrier gases such as helium or hydrogen; its performance is similar to the thermal conductivity detector. Helium was then expensive in Europe and hydrogen was unacceptable for use in a high-temperature apparatus expected to run overnight unattended. I was obliged therefore to use nitrogen as the carrier gas—as did Martin and James with their gas density balance. It was easy enough to confirm Boer's performance figures, but these were miserably insensitive when

"My new task was to work on the preservation of life in the frozen state. This would seem to have little to do with gas chromatography or electron capture, but it so happened that a key factor in determining the resistance of a living cell to freezing was the composition of fatty acids in the cell membrane. . . .

By great good fortune, my laboratory was only a few yards from that of Archer Martin and Tony James. They were using their newly-invented gas chromatograph to analyse fatty acid esters."

In 1951, having by then discovered little more about the common cold other than that it was not caught by chilling, I was moved back to our parent institute in London. My new task was to work on the preservation of life in the frozen state. It culminated in 1953 with successful freezing and reanimation of a golden hamster. This would seem to have little to do with gas chromatography or electron capture, but in the strange and serendipitous ways of science it so happened that a key factor in determining the resistance of a living cell to freezing was the composition of the lipids of the cell membrane. Cells whose membrane lipids were highly saturated were more easily damaged by freezing than were those membrane lipids that were rich in polyunsaturated fatty acids. Before gas chromatography, the analysis of fatty acids was a slow and laborious business requiring samples much larger than the few milligrams we then had available. By great good fortune, my laboratory was only a few yards away from that of Archer Martin and Tony James. They were using their newly-invented gas chromatograph to analyse fatty acid methyl esters. It was not long before a col-

compared with those of Martin's gas density balance. The first ionization detector did not seem to be promising.

Sometimes when one is confronted with a failed experiment or an unsatisfactory device, it is better to cut one's losses and move on to something else. In this instance, however, I remembered the success of the ion anemometer and how its sensitivity was very dependent upon the applied potential. I thought it at least worth trying a few experiments to see if different ranges of applied potential would improve the performance of the ionization cross-section detector.

It was easiest to try low potentials first. I soon found that if the detector was polarized with less than 30 V, the ion current in pure nitrogen became a little less, but that when other substances were present, it became much less. James had supplied me with a test mixture of fatty acid methyl esters, from methyl propionate to methyl caproate. With the detector operating at 100 - 300 V, 1 mg of this mixture gave four small peaks, (caused by increased ion current when certain sample components were present). When I tried it with only 10 V and reversed the

"I shall never forget the look of amazement on Tony James's face. Peak after peak appeared on the chromatogram of his allegedly pure sample of methyl caproate, and none of these peaks had the retention time of methyl caproate or any other fatty acid ester. We now know that what we saw were traces of electron-absorbing impurities in the sample."

recorder connection to reveal negative peaks (indicating decreased ion current), the 1-mg sample gave what seemed to be a never-ceasing range of off-scale peaks. I thought that the search was over and that we now had a truly sensitive detector. I asked James and Martin to come try it, which they did, bringing with them an allegedly pure sample of methyl caproate. I shall never forget the look of amazement on Tony James's face as peak after peak was drawn from a small sample of this substance and none of them with the retention time of methyl caproate or of any other fatty acid ester. We now know that what we saw were traces of electron-absorbing impurities in the sample, but at that time it seemed to be a useless and wholly anomalous device.

In spite of this disappointment, I continued to play with it whenever there was time, and by trying compounds chosen at random from the lab shelves I discovered a certain sense in its behaviour. It seemed to respond to polar compounds like ketones and alcohols but not to hydrocarbons and ethers. But when I tried a mixture of compounds made up in the nonpolar solvent carbon tetrachloride, the ion current fell to zero and remained there, resisting all attempts to restore normal operation. I later realized how unwise it was to connect the column to the detector using a silicone rubber seal, which became an almost permanent source of the vapour of that intensely electron-absorbing substance, carbon tetrachloride.

For the ordinary gas chromatograph, we clearly needed something more sensitive than the original ionization detector but less temperamental than the electron capture detector. I wondered if other ionization processes might be exploited to detect the vapors of organic compounds in a nitrogen carrier gas.

This line of thought led by a happy accident to the discovery of the "argon" detector. This device detects the ion current resulting from ionization of sample molecules by metastable argon ions (formed when the gas is exposed to a radioactive source). For a brief few years this was the principal sensitive detector used in gas chromatography. It was, of

course, replaced by the even better flame ionization detector.

During the spring of 1959, I made a brief visit to New York to read a paper on the argon detector and while there met Sandy Lipsky. He invited me to visit his laboratory at Yale for the coming academic year. My first thought was to decline this invitation, but Sandy Lipsky soon convinced me that Yale would provide a kind, hospitable environment conducive to creative work, which it certainly did. Relieved of the need to spend most of my time on biochemical problems, I was able to develop the argon detector especially for use with capillary columns.

The other main project at Yale was the development of the electron capture detector. We chose to develop it as a qualitative device—in particular one that could distinguish functional groups among the vast range of compounds resolved by capillary columns from natural products. At that time the mass spectrometer was too expensive and too insensitive for this need. Another reason for applying this detector to qualitative analysis was that we doubted its utility in quantitative analysis. The versions polarized by a small fixed potential performed erratically and sometimes even gave false and irreproducible signals.

During this time at Yale, the key to the cure of the electron capture detector's bad habits came from an encounter with McAfee of Bell Telephone Laboratories. He had developed a pulse method for observing electron attachment in a drift tube. After I considered his idea, it occurred to me that most difficulties with the detector could be resolved if electrons were collected by brief pulses of high potential, rather than by letting them drift under the influence of a weak electrical field. The high-potential pulses overcame the all-too-frequent contact potentials and space charges that unpredictably either enhanced or opposed electron collection.

I believe the first application of the electron capture detector to environmental problems was for pesticide residue analysis. The demonstration of the ubiquitous distribution of pesticides throughout the global environment did much to fuel the environmental revolution that followed.

Analysts were probably not too perturbed by the assertions of academic scientists that theory proved the detector should not work. However, some chemical physicists were justifiably annoyed when they saw their neat and orderly work on ion-molecule reactions trodden over by what seemed to be a mob of clumsy peasants. It is only fair to add that a year or so later the same critics confirmed the validity of measurements using the electron capture detector.

I find it helpful to think of the detector as a small reaction vessel holding a dilute suspension of the reagent chemical, gaseous free electrons. It is interesting that the free electron, in thermal equilibrium with a gas at ambient temperature, behaves as if it were a very large particle, larger even than most of the molecules it encounters. This large cross section reflects the great rapidity of electron reactions which accounts for the sensitivity of the detector. The chemical reaction between electrons and molecules is second-order, and many analysis

problems arise from this fact. If the electron capture detector were insensitive, and the number of molecules present was vastly greater than the number of electrons, the device would be splendidly linear and predictable in its response. Unfortunately, at the trace concentrations which analysts try to measure with the electron capture detector, the numbers of molecules in the detector are comparable with the number of electrons. In such circumstances, as any textbook of physical chemistry would tell you, the response of the detector to varying sample size is unlikely to be either linear or easily predictable.

As experience in the analysis of different molecular species by electron capture grew, an odd and interesting association between electron capture and biological activity grew ever more apparent. The great bulk of electron-absorbing substances fell into two categories: those that were important components of biological energy transport systems and those that were highly toxic or carcinogenic.

It was tempting to speculate that the free electron might be a fundamental particle of biology as well as of chemistry and physics. It was a challenging coincidence that each alternate acid of the Krebs cycle (the major pathway for the oxidation of lipids and carbohydrates) was one of the few organic compounds that reacted vigorously with free electrons. These include pyruvate, oxaloacetate, fumarate, ketoglutarate, and *cis* aconitate. The coenzymes ubiquinone and DPNH are also electron-attaching, as well as compounds such as the thyroid hormones,

which are able to mediate in this system. Other electron-attaching compounds are the iodo- and nitrophenols, which are toxic and act by uncoupling oxidative phosphorylation. It is still unclear whether this association is real or coincidental, but there is no doubt that a remarkably high proportion of electron absorbers are biologically active, which makes the electron capture detector so important a device in environmental science.

Nowadays, whenever I come across a chemical substance that is strongly electron-absorbing, I tend to regard it cautiously. I well recall it being argued that the apparent association between carcinogenesis and electron capture was illusory, since so many of the halocarbons were not carcinogenic. Vinyl chloride and trichloroethylene were both quoted as examples of substances safe enough for use as anesthetics in surgery. Now, of course, we know them to be carcinogenic.

In 1966 we purchased a holiday cottage in far western Ireland; during the first summer there I noticed that whenever the wind came from the east, the air was very hazy. The haze looked and smelled like smog. When I returned to England I asked colleagues who were meteorologists or atmospheric chemists if smog could travel the 1000 km from Europe to Ireland. They were skeptical and suggested instead that what I had seen was probably a natural exhalation of the Irish bogs. I was not convinced by their plausible arguments and next summer, much to the annoyance of my wife and family, I brought a

"I asked colleagues who were atmospheric chemists if smog could travel the 1000 km from Europe to Ireland. They suggested that I had probably seen a natural exhalation of the Irish bogs. I was not convinced by their arguments and next summer, much to the annoyance of my wife and family, I brought a portable gas chromatograph to our holiday cottage in Ireland.

The measurements established the presence of a small steady concentration of F11 (ozone) in the clear air, whose concentration rapidly tripled when the wind direction changed . . . The haze was indeed man-made smog, (but) I wondered about the source of the small background level of F11 in the clear air. Was it pollution blown across the Atlantic from America? Or could it be that these very stable compounds were accumulating in the atmosphere on a global scale?"

Extraordinary coincidences underlie many fundamental scientific discoveries

Most chemists have acquired their basic knowledge of chemistry in university courses, where (most understandably) chemistry is presented in a logical, systematic way. Consequently, they generally assume that our present understanding of chemical principles was derived by a similar systematic "scientific" approach. This impression is not consistent with historical facts, which show that many important discoveries were a consequence of extraordinary coincidences and chance events.

It is well known, for example, that Alexander Fleming's discovery of penicillin followed the inadvertent contamination of a bacteria culture by the mould *penicillium*. The discovery would never have happened if Fleming had been more meticulous about sterilizing old culture plates. It is often assumed that contamination by the mould *penicillium* might have occurred in other laboratories, but that less observant researchers had not recognized the ability of this mould to destroy bacterial cells. The truth of the matter, as W. I. B. Beveridge describes in his book *Seeds of Discovery*, is that Fleming's discovery was based on an extraordinary series of chance events. Other researchers had great difficulty reproducing the same destruction of staphylococcal bacterial colonies, even when the culture was deliberately inoculated with a known penicillin-producing mould.

Many similar examples are cited in Beveridge's book. In reviewing the book for *Chemical & Engineering News* (in the 22 February issue, page 40), Rostum Roy interjects his own reflections upon the role of chance, not only in scientific discoveries, but in all human affairs. He points out that "no Western philosophy has attempted to factor in the profound role that chance plays in our lives. Indeed, one might well say that, for some strange reason, the entire Western ethos has been the saga of human will attempting to conquer the vicissitudes of fate." Roy feels that this biased cultural background predisposes scientists to disregard—and even dismiss—the role of chance. It would seem quite understandable, however, that scientists would allow their view of former discoveries to be biased by their own knowledge, based on information gleaned years after the original discovery. Chance events seem much less important for understanding and explaining experimental results when one has the benefit of hindsight.

The chemical literature contains an abundant supply of cases where chance played a key role in important scientific discoveries. One prominent example is the discovery of radioactivity by Henri Becquerel, which came about by a remarkable coincidence. The events leading to the discovery were described in the December 1981 issue of the *Bulletin of the International Atomic Energy Agency*. An abridged account is presented here:

On the evening of 8 November 1895, Röntgen was working with a Hittorf - Crookes discharge tube in a carefully darkened room. He noticed that when an electrical discharge took place in the tube, there was a faint greenish glow (fluorescence) in a piece of cardboard coated with barium platinocyanide positioned near the tube. By covering the discharge tube with a black shield impervious to visible light, Röntgen was able to verify that the tube was the source of a new kind of radiation (to be called "X-rays"). The radiation was invisible, but revealed its existence when it struck a luminescent screen.

In the early work with X-rays, it was soon recognized that the spot in the discharge tube where the "cathode rays" (electrons) caused the emission of X-rays was also characterized by a strong fluorescence. The apparent correlation between fluorescence and emission of X-rays led Becquerel to suspect that the two phenomena might be closely related. In 1896, Becquerel undertook a systematic study of the relationship between the emission of visible light and X-rays. He exposed phosphorescent substances to sunlight, wrapped them in black paper, and placed them on photographic plates to detect any X-rays that might be emitted.

This was a reasonable experiment for Becquerel to undertake, although from the viewpoint of a present-day scientist, his hypothesis seems incredibly naive. We now know that X-ray emission is not caused by phosphorescence (but rather, the opposite), and that Becquerel's experiment was doomed to failure. Or was it?

It so happened that Becquerel started his experiments with highly fluorescent uranium compounds. When he developed his photographic plates, he found that black spots were present on the film where the uranium minerals had been placed. He initially concluded that exposure of the uranium minerals to sunlight had induced the emission of X-rays. However, Becquerel later developed a photographic plate that had lain for several days in a drawer under a tray with uranium salts which had *not* been exposed to sunlight, and found the same dark spots on the plate. He repeated the experiment and concluded that neither sunlight, phosphorescence nor fluorescence was necessary to produce the effect, and that invisible rays were emitted from all uranium compounds and from metallic uranium. This marks the discovery of radioactivity.

The inference to be drawn from the experiences of Fleming, Becquerel and other scientists is that chance events play an integral part in scientific research. All scientists are subject to this powerful force, which can thrust a project ahead in a sudden surge of progress, or dash its outlook for a successful conclusion. The best course seems to be for chemical researchers to ride with the waves of fate, rather than struggle against them.

portable gas chromatograph with me. My objective was to measure the atmospheric concentration of trichlorofluoromethane (F11) before, during and after one of the outbreaks of hazy air. I chose to look for F11 rather than a typical smog chemical such as ozone or peroxyacetyl nitrate (PAN) because the fluorocarbons alone are unequivocally man-made. The other substances I knew would be regarded by my doubting colleagues as possible emissions from natural sources.

The measurements soon established the presence of a small steady background concentration of F11 in the clear air, about 50 parts-per-trillion by volume. When the haze appeared, the concentration rapidly tripled and remained at this level until the wind changed direction and clear air returned.

The measurements proved that the haze was indeed man-made smog and later observations revealed a close correlation between the concentrations of F11, ozone, and other smog chemicals. While not denying the interest and importance of regional air pollution, which has now become a topic in its own right, I found my own interest was stirred to wonder about the source of the small background level of F11 in the clear air. Was it pollution blown across the Atlantic from America? Or could it be that these very inert and stable compounds were accumulating in the atmosphere on a global scale?

To seek answers to these questions, I set sail aboard the research ship *Shackleton* in November 1971, bound for the southern hemisphere. I measured the concentration of F11 and other halocarbons and that of the natural sulphur carrier dimethyl sulphide. We made measurements several

"Analysts were probably not too perturbed by the assertions of academic scientists that theory proved the detector should not work. Some chemical physicists were justifiably annoyed when they saw their neat and orderly work on ion - molecule reactions trodden over by what seemed to be a mob of clumsy peasants."

times daily in air and seawater. The voyage lasted nearly six months; the measurements in Antarctica and on the return to England were made by my colleagues Bob Maggs and Roger Wade. These observations clearly indicated an accumulation of F11 in the atmosphere. They formed the basis upon which Molina and Rowland were able to build their famous theory of the chlorine-catalysed depletion of stratospheric ozone.

The holiday cottage in Ireland where it all began has now become a monitoring station, one of a global network dedicated to the task of observing the concentration and growth rate of the halocarbons in the global environment.

Abbreviations and Symbols for Specifying the Conformation of Polynucleotide Chains (*Provisional*)

General principles of notation are first described, defining chain direction and the nucleotide unit, and specifying nomenclature for atom numbering, bond lengths, bond angles, torsion angles and conformational regions. The description of conformations for the bonds of the nucleotide unit is then given in detail for the sugar - phosphate backbone, the sugar ring, the *N*-glycosidic bond and the orientation of side groups. Recommendations are also made for the description of hydrogen bonds, base pair schemes and helical segments of polynucleotide chains. General examples of conformations are illustrated. The proposed nomenclature is consistent with that recommended for conformations of polypeptides and polysaccharides.

This report, prepared by the Joint Commission on Biochemical Nomenclature will be published in the *European Journal of Biochemistry*, and in *Pure & Applied Chemistry*. Publication is anticipated for late 1982.

Comparison of the abilities of trace analytical methods to determine small amounts of concentrations of elements (Part V. General Aspects of Trace Analytical Methods)

With the increasing proliferation and development of analytical instrumentation for trace element analysis, it is desirable to be able to compare the concentration levels at which they can be applied to each element. This report achieves this comparison by quoting realistic "limits of determination" for each element and a range of the more common instrumental techniques, viz. Molecular absorption spectrometry, flame and electrothermal atomic absorption spectrometry, atomic fluorescence spectrometry, emission spectrography (d.c. arc, spark), I.C.P. and flame emission spectrometry, X-ray fluorescence spectrometry, spark-source mass spectrography, neutron activation analysis, d.c. linear sweep and pulse polarography, stripping voltammetry and ion-selective electrode potentiometry. For most techniques, the limit of determination is defined as $10 |S_{bl}|$, where $|S_{bl}|$ is the standard deviation of the blank, and is the lowest amount or concentration that can be measured quantitatively. Such a treatment is necessarily approximate, and limits of determination are continually being lowered. Nevertheless, the data does provide a reasonable basis for comparison of the applicability of the techniques considered at the present time.

This report, prepared by the Commission on Microchemical Techniques and Trace Analysis will appear in *Pure & Applied Chemistry* in Autumn of this year.

Symbols for Specifying the Conformation of Polysaccharide Chains (*Provisional*)

The notation for atomic numbering, interatomic distances, bond angles and ring shapes are described, and the rules for defining conformation of various side groups are discussed and illustrated. Residues are numbered from the reducing end, so that terminal transglucosylation does not alter the numbering of every residue in a chain. The glycosidic swivel joints are designated and the convention for torsion angles is given.

This report, prepared by the Joint Commission on Biochemical Nomenclature will be published in the *European Journal of Biochemistry* and in *Pure & Applied Chemistry*. Publication is anticipated for late 1982.

Recommended standards for reporting photochemical data (*Provisional*)

The assessment of reinterpretation of experimental results requires that the reports contain sufficient information about experimental procedures and conditions. This is, of course, especially important in order to allow repetition of experiments by other investigators. While some experimental practices are so standard or common as to be assumed, many are not. It is, therefore, important that the crucial experimental parameters be included in published reports.

The purpose of this document is to recommend a comprehensive set of experimental parameters and data manipulation methods that should be reported in published accounts of photochemical investigations and attendant spectroscopic studies.

The following aspects are covered in these recommendations:

I. Photochemical Reactions

- A. Conditions
- B. Quantum Yields
- C. Chemical Yields
- D. Kinetics

II. Absorption Spectroscopy

- A. Display
- B. Conditions
- C. Transient absorption and flash kinetics
- D. Action spectra

III. Luminescence Spectroscopy

- A. Display
- B. Conditions
- C. Kinetics
- D. Luminescence yield
- E. Excitation spectra
- F. Chemiluminescence

IV. Abstract

Preparation of this report was coordinated by Dr. A. A. Lamola and Professor M. S. Wrighton for the IUPAC Commission on Photochemistry. The report will be published in *Pure & Applied Chemistry* in the latter half of 1982.

IUPAC meetings are indicated in bold type
Additional information from address in parenthesis

1982

SOLID COMPOUNDS OF TRANSITION ELEMENTS

June 21 - 25. 7th International Conference on Solid Compounds of Transition Elements. Grenoble, France

(E. F. Bertaut, C.N.R.S., Laboratoire de Cristallographie, 166 X, 38042 Grenoble Cedex, France.)

SOLUTE - SOLVENT INTERACTIONS

July 4 - 10. 6th International Symposium on Solute - Solute - Solvent Interactions. Minoo, Osaka Prefecture, Japan.

(Prof. Hitoshi Ohtaki, Department of Electronic Chemistry, Tokyo Institute of Technology at Nagatsuta, Nagatsuta-cho, Midori-ku, Yokohama, 227 Japan.)

COMPUTERS IN CHEMICAL RESEARCH

July 11 - 16. 6th International Conference on Computers in Chemical Research and Education (ICCCRE). Washington, DC, USA.

(Dr. Stephen R. Heller, Chairman, 6th ICCCRE, EPA, MIDSD, PM-218, 401 M Street, SW, Washington, DC 20460, USA.)

PHYSICAL ORGANIC CHEMISTRY

July 11 - 16. 6th IUPAC Conference on Physical Organic Chemistry. Louvain-la-Neuve, Belgium.

(Prof. A. Bruylants, Université Catholique de Louvain, Laboratoire de Chimie Générale et Organique, Bâtiment Lavoisier, 1 Place Louis Pasteur, 1348 Louvain-la-Neuve, Belgium.)

MACROMOLECULES

July 12 - 16. IUPAC Macromolecular Symposium. Amherst, MA, USA.

(James C. W. Chien, Department of Polymer Science & Engineering, University of Massachusetts, Amherst, MA 01003, USA.)

SELECTIVE POLYMER SORBENTS

July 19 - 22. 23rd Prague Microsymposium "Selective Polymer Sorbents". Prague, Czechoslovakia.

(Dr. F. Svec, c/o Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského n. 2, 162 06 Prague 616, Czechoslovakia.)

NON-AQUEOUS SOLUTIONS

July 19 - 23. 8th International Conference on Non-Aqueous Solutions. Nantes, France.

(Pham van Huong, Laboratoire de Spectroscopie Infrarouge et Raman, Université de Bordeaux I, F-33405, France.)

PHOTOCHEMISTRY

July 25 - 30. 9th IUPAC Symposium on Photochemistry. Pau, France.

(Prof. J. Joussot-Dubien, Laboratoire de Chimie Physique A, Université de Bordeaux I, F-33405 Talence, France.)

MARINE NATURAL PRODUCTS

July 26 - 30. 4th International Symposium on Marine Natural Products. Tenerife, Canary Islands, Spain. (Prof. A. G. Gonzalez, Department of Organic Chemistry, University of La Laguna, Tenerife, Spain.)

NATURAL PRODUCTS

August 2 - 7. 13th International Symposium on Chemistry of Natural Products. Pretoria, South Africa.

(Mrs. Jeanne Beck, Symposium Secretariat, S.219, CSIR, POB 395, Pretoria 0001, Republic of South Africa.)

EFFLUENTS OF COAL-FIRED PLANTS

August 16 - 18. International Conference on Coal-Fired Power Plants and the Aquatic Environment. Copenhagen, Denmark.

(Mr. P. Schjodtz Hansen, Director VKI (Water Quality Institute), 11, Agern Alle, DK-2970 Horsholm, Denmark.)

ORGANIC SYNTHESIS

August 22 - 27. 4th International Conference on Organic Synthesis. Tokyo, Japan.

(Prof. Teruaki Mukaiyama, Department of Chemistry, Faculty of Science, The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113, Japan.)

CARBOHYDRATES

August 22 - 28. 11th International Carbohydrate Symposium. Vancouver, Canada.

(Dr. G.C.S. Dutton, Department of Chemistry, University of British Columbia, Vancouver, BC, V6T 1Y6, Canada.)

COORDINATION CHEMISTRY

August 23 - 27. 22nd International Conference on Coordination Chemistry. Budapest, Hungary.

(Prof. M. T. Beck, Institute of Physical Chemistry, Kossuth Lajos University, Debrecen 10, H-4010, Hungary.)

POLYMER STRUCTURE & PROPERTIES

Aug. 29 - Sept. 2. "Interrelations between Processing, Structure and Properties of Polymeric Materials. Athens, Greece.

(Prof. P. S. Theocaris, Chair of Applied Mechanics, National Technical University of Athens, Athens, Greece.)

PESTICIDE CHEMISTRY

Aug. 29 - Sept. 4. 5th International Congress of Pesticide Chemistry. Kyoto, Japan.

(Rikagaku Kenkyusho (The Institute of Physical and Chemical Research), 2-1 Hirosawa Wako-shi Saitama Pref 351, Japan.)

MASS SPECTROMETRY

Aug. 30 - Sept. 3. 9th International Mass Spectrometry Conference. Vienna, Austria.

(Univ. Prof. Dr. J. F. Huber, Institute of Analytical Chemistry of the University of Vienna, Währingerstr. 38, A-1090 Vienna, Austria.)

THEORETICAL CHEMISTRY

Aug. 30 - Sept. 3. International Symposium on Theoretical Organic Chemistry. Durbrovnik, Croatia, Yugoslavia.

(Dr. Ante Graovac, Institute "R. Bosković", POB 1016, 41001 Zagreb, Yugoslavia.)

MYCOTOXINS AND PHYCOTOXINS

Aug. 31 - Sept. 2. 5th International IUPAC Symposium on Mycotoxins and Phycotoxins. Vienna, Austria.

(Prof. Palle Krogh, Head, Department of Microbiology, Royal Dental College, Juliane Mariesvej 30², DK-2100 Copenhagen Ø, Denmark.)

RAMAN SPECTROSCOPY

September 6 - 12. 8th International Conference on Raman Spectroscopy. Bordeaux, France.

(Prof. J. Lascombe, Université de Bordeaux I, 33405 Talence Cedex, France.)

CHEMICAL THERMODYNAMICS

September 7 - 10. 7th International Conference on Chemical Thermodynamics. London, UK.

(Prof. M. L. McGlashan, Department of Chemistry, University College London, 20 Gordon Street, London WC1H 0AJ, UK.)

CHEMISTRY RELATING TO AGRICULTURE

December 6 - 10. Chemical Research to Meet the World's Expanding Food Needs (CHEMRAWN 11) Manila, Philippines.

(Dr. Charles S. Dennison, Executive Director, Council on Science & Technology for Development, 2010 Massachusetts Avenue NW, Washington, DC 20036, USA.)

1983

OILS, FATS & WAXES

February 13 - 17. International Conference on Oils, Fats & Waxes. Auckland, New Zealand.

(Mr. S. G. Brooker, Department of Chemistry, University of Auckland, Private Bag, Auckland, New Zealand.)

IUPAC CONGRESS

June 4 - 12. 29th International Congress of Pure & Applied Chemistry. Cologne, Federal Republic of Germany.

(General Secretariat of the 29th IUPAC Congress, Dr. W. Fritsche, c/o Gesellschaft Deutscher Chemiker, P.O. Box 900440, D-6000 Frankfurt/M 90, Federal Republic of Germany.)

SPECTROSCOPY

June 26 - July 1. 23rd Colloquium Spectroscopicum Internationale. Amsterdam. The Netherlands.

(23rd CSI c/o Organisatie Bureau Amsterdam BV, Europaplein, 1078 GZ Amsterdam, The Netherlands.)

PROPERTIES OF COPOLYMERS

July 11 - 14. 24th Prague Microsymposium: Copolymers, Structure and Solution Properties. Prague, Czechoslovakia.

(Dr. P. Kratochvíl, c/o, Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského n. 2, 162 06 Prague 616, Czechoslovakia.)

ANALYTICAL CHEMISTRY

July 17 - 23. SAC 83 Conference and Exhibition, organised by the Analytical Division of the Royal Society of Chemistry, University of Edinburgh, Edinburgh, UK.

(Dr. J. M. Ottaway, Department of Pure & Applied Chemistry, University of Strathclyde, Cathedral Street, Glasgow G1 1XL, UK.)

POLYMER STABILITY & PROCESSING

July 18 - 21. 25th Prague Microsymposium: Processing and Long-term Stabilities of Hydrocarbon Polymers. Prague, Czechoslovakia.

(Dr. J. Pospíšil, c/o, Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského n. 2, 162 06 Prague 616, Czechoslovakia.)

TOXICOLOGY OF METALS

July 20 - 23. 2nd International Symposium on Clinical Chemistry and Chemical Toxicology of Metals. Montreal, Canada.

(Dr. J. Savory, University of Virginia Medical Center, Department of Pathology, Box 168, Clinical Laboratories, Charlottesville, VA 22908, USA.)

IUPAC GENERAL ASSEMBLY

August 18 - 26. 32nd IUPAC General Assembly. Lyngby/Copenhagen, Denmark.

(IUPAC Secretariat, 2 - 3, Pound Way, Cowley Centre, Oxford OX4 3YF, UK.)

POLYMERIZATION OF HETEROCYCLES

September. International Symposium on Polymerization of Small Heterocycles and Aldehydes. Poland.

(Prof. Z. Jedliński, Polish Academy of Sciences, Polymer Institute, POB 49, Curie-Skłodowskiej 34, PL-41 800 Zabrze, Poland.)

MACROMOLECULES

September 5 - 9. 29th International Symposium on Macromolecules. Bucharest, Romania.

(Acad. Cristofor Simionescu, Institutul de Chimie Macromoleculara Petru Poni Aleea Grigore Ghica Voda Nr. 41A, Iasi, Romania.)

1984

NATURAL PRODUCTS

July 9 - 14. 14th International Symposium on the Chemistry of Natural Products. Poznan, Poland.

(Prof. Dr. Maciej Wiewiórowski, Institute of Bioorganic Chemistry, Polish Academy of Sciences, ul. Noskowskiego 12/14, 61-704 Poznan, Poland.)

ORGANIC CHEMISTRY

August. 7th IUPAC Conference on Physical Organic Chemistry. Auckland, New Zealand.

(Conference Secretary, Professor B. R. Davis, Chemistry Department, University of Auckland, Private Bag, Auckland, New Zealand.)

RAMAN SPECTROSCOPY

Aug. 26 - Sept. 1. 9th International Conference on Raman Spectroscopy. Japan.

(Prof. Mitsuo Tasumi, Department of Chemistry, Faculty of Science, The University of Tokyo, Bunkyo-ku, Tokyo 113, Japan.)

BIOTECHNOLOGY

November/December. 7th International Biotechnology Symposium. New Delhi, India.

(Prof. T. K. Ghose, Chairman, National Organisation Committee & Head, Biochemical Engineering Research Centre, Indian Institute of Technology, Hauz Khas, New Delhi-110029, India.)

Chemistry International

is the news magazine of the

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The International Union of Pure and Applied Chemistry (IUPAC), formed in 1919, is a voluntary, non-governmental, non-profit association of organizations, each of which represents the chemists of a member country.

Its objectives are:

to promote continuing co-operation among the chemists of the member countries;

to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;

to co-operate with other international organizations which deal with topics of a chemical nature;

to contribute to the advancement of pure and applied chemistry in all its aspects.

The membership of IUPAC presently comprises 43 countries, each represented by a national organization, such as an academy of science or research council.

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Cover: An experimental solid-state battery, shown here about 5× actual size, being tested in Prof. Brian Steele's laboratory at Imperial College, London. This battery, and similar ones being developed by other groups, might be the forerunners of new electrochemical power units that will store far more energy than conventional batteries, be completely free of corrosion, might be charged and discharged thousands of times, and would retain their charge for unlimited periods.

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OF THE LABORATORY WORKER

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Scientists play a leading role in forming high-technology industries

In 1937, the physicist Edwin Land conceived the idea to form a "science-centered" company which based its profits on technological innovations generated through its own research. He was one of the first scientists to bring research into industry, to prove the potential of research to make money, and to demonstrate the ability of scientists to undertake commercial ventures. During the 45 years since he started his company, Land established Polaroid Corporation as a major international company, with annual sales of about US\$1.5 billion. This successful venture pioneered the way for other scientists to venture into the business world, an environment that had previously been considered entirely alien and somewhat inappropriate for an individual with scientific training. Since then, scientists who have gone into business have become accepted by their colleagues, both in the scientific community and in the business world.

In the 1960's and 1970's semiconductor and computer manufacture formed the basis of a new high-technology industry, and fostered the formation of new companies by scientists and engineers. Some of the fledgling companies which entered this field have now become world leaders. The main high-technology growth area within the last few years has been biotechnology. Development of laboratory techniques for manipulating and transposing DNA has created fertile areas for new commercial ventures. About one hundred biotechnology companies have been formed throughout the world to exploit recombinant DNA techniques to manufacture synthetic vaccines, hormones and enzymes. The driving force behind the formation of these companies has been the enthusiasm of individual chemists, biochemists and microbiologists on the forefront of this new technology.

Perhaps it is within the very nature of science that scientists should yearn to start their own company. Scientists are creative people, and often have expertise leading beyond the technology in present commercial use. However, forming a high-technology company is a risky undertaking, requiring abilities that are not normally sought or developed in scientists. Being at the forefront of technology may

provide an open field for new advances, but it also gives rise to unpredictable and rapidly-changing events. Many companies that were based on sound scientific developments and staffed by technically-capable people have failed—not because they could not achieve the technical advances that they sought, but because they misjudged the market. Blazing new commercial trails can be highly profitable, but it is usually difficult and demanding. It can, no doubt, also be very lonely. To be successful, the scientist-entrepreneur must be prepared to go on his own into new areas that have not been explored by competitors. He must generate the impetus, from within his own character, to carry the company forward. As one scientist-entrepreneur points out, "you can tell a pioneer by the arrows in his back".

Most scientists who have formed successful companies have been skillful (or lucky) at judging the market, as well as being technically competent. They have avoided the common mistake of becoming pre-occupied with new technology. Rather, they have utilized new technology as a means to cater to existing market demands. Scientists often start out with specific expertise or knowledge, which they regard as a "solution in search of a problem". Successful scientist-entrepreneurs usually take the opposite approach: they start by identifying an existing or potential problem, and then developing the technology necessary to solve it. Experiences of several scientists who have formed successful companies are discussed in an article "The physicist as entrepreneur", published in the January 1982 issue of *Physics Today*. It contains excellent guidance for any scientist who might contemplate starting his own company. Although the advice of these scientist-entrepreneurs is sometimes contradictory, their views strongly reinforce one another in most respects. Several conclusions consistently emerge from their experiences, and these convey a clear impression of those factors which are critical in determining the success or failure of new technology-based ventures.

Successful scientific commercial ventures are able to bring together existing or new technology with the needs of the marketplace. They are not only able to develop a new pro-

duct or service, but are able to market it. Many people have come to believe blindly the adage that "those who build a better mousetrap will find the world beating a path to their door". This is often not true, especially for a new company with a new product. Your research may be brilliant and your product first class, but no one will know about your product or buy it unless you beat a path to *their* door. Before a new product is developed, the entrepreneur must anticipate whether people will want to buy it, how much they are prepared to pay, and how the product can best be advertised and sold. Few scientists have any experience in marketing, although this deficiency might not be as serious as one would expect. Even highly-trained marketing specialists can completely misjudge the market for a new product. The introduction of new technology into the marketplace can create secondary effects and interactions that are impossible to predict. If one had tested the market for semiconductors when they were first developed, the only obvious applications would have been in hearing aids. No one could have forecast the enormous improvements in operating characteristics of transistors, the major reductions in cost as new production methods were perfected, or the development of fabrication techniques allowing hundreds of transistors to be formed on a single integrated circuit chip. Similarly, no one predicted the synergistic relationship which was to develop between the semiconductor and computer industries, with each industry supporting the growth of the other. In the same way, the market for photocopying machines had been grossly underestimated. It is extremely difficult for anyone to confidently predict the demands of the marketplace a few years hence. As Edwin Land recently stated during an address to the Chemical Institute of Canada, "Very often, the best way to find out whether something is worth making is to make it, distribute it and then to see (after the product has been around for a few years) whether it was worth the trouble."

Even if the potential market of a new product is correctly assessed, this does not necessarily guarantee that its development and manufacture will be financially viable. A special problem associated with research and development of high-technology products is that a great deal of time and money must be invested before any sales can be made. This problem is especially acute when a new drug product, food additive or pesticide is to be manufactured, and a lengthy testing programme is required to establish the safety of the product. Only very large organizations with substantial resources can sustain the funding required for an extended research and development project. The smaller company must generally develop a new product or service in stages, so that sales at each stage can generate a flow of income to pay for further research. This, in fact, highlights one of the basic differences in approach that differen-

tiates the large established corporation from the new small company.

By the very nature of their size, large multinational corporations tend to be less responsive to the needs of the marketplace (and, some would argue, less innovative). They must sustain high-volume production in order to offset their huge cost overheads and to achieve lower costs through economies of scale. Large companies are generally not interested in small, highly-specialized segments of the market. These niches are readily met by small companies. They can be more flexible in responding to the needs of clients, tailoring the product or service to meet the customer's specific requirements. However, a small company has limited financial resources. It must achieve its objectives in the best and simplest way. Large companies, on the other hand, can afford to solve problems in ways that are less direct or efficient, compensating for lack of ingenuity by investing more money in equipment or advertising.

Most high-technology companies originate as a "spin-off" from an established company. Usually, a scientist working for an existing company gets an idea that his employer is not willing to pursue. If the individual is convinced of the viability of his idea, he might form his own company.

Some scientist-entrepreneurs become so obsessed with protecting their ideas that they are not prepared to discuss their ideas with financial backers. The need for secrecy is probably overestimated, some feel, and is actually destructive if it approaches paranoia. The basic idea for developing a new product comprises only perhaps 10% of what is needed for a successful venture. Another 15% of the "formula for success" is a detailed business plan showing that the product can be manufactured and marketed, that the cost of equipment needed to make the product does not push the price beyond what people are prepared to pay, and that there is some group of customers who would be willing to buy the product soon after it was introduced. However, conditions may later change, forcing the entrepreneur to adopt a new business plan and perhaps modify his original idea. The most important factor determining whether a business succeeds or fails, most agree, is the people who run it. They must be sufficiently inventive and adaptive to withstand these changes and recover from setbacks. Successful entrepreneurs tend to be future-oriented, but not dreamers. They obviously must have confidence in themselves and their ideas, yet be realistic about what they can expect to accomplish. The one pitfall they must avoid is a loss of confidence brought about by failure to meet their own self-imposed goals. Successful entrepreneurs tend to be persistent, sometimes almost fanatical. They must be convinced that their idea will work, and most important of all, they must be right.

Research-based companies proliferate by technological spin-off

In business, as in chemical research, advances in one area often lead to innovations in other areas. However, the industrial researcher who uncovers an exciting new application for available technology and research skills may find that his company is unwilling to develop his ideas. Most companies are, in fact, reluctant to venture beyond the boundaries of their technical and marketing expertise. Rather than allow their ideas to languish, a few enterprising chemists have taken the initiative to launch new commercial ventures. The recent development of the microelectronics and biotechnology industries, for example, was based largely on the enterprise of frustrated researchers who formed their own companies, using spin-off technology from their previous work.

In the chemical industry, a good example of technological spin-off is provided by several new chemical ventures which germinated within the pharmaceutical company Syntex. Syntex was itself an extremely innovative company, which—although tiny in comparison to the major multinational pharmaceutical companies—was a leader in the development of synthetic steroids and the contraceptive pill. It attracted bright innovative chemists and biochemists by providing challenging assignments and an extraordinary freedom to publish results—sometimes even before patents had been granted.

One of its research staff, Dr. Alejandre Zaffaroni, made an important contribution to steroid research by developing a method to separate steroid compounds by paper chromatography. Gradually, Dr. Zaffaroni became increasingly involved with the company's management decisions. While working as Associate Director of Syntex's biological research department (and later, supervising research and marketing as Executive Vice-President), Dr. Zaffaroni developed a keen interest in marketing strategy. He became convinced that the research program at Syntex, and of other pharmaceutical companies, bypassed an important little-recognized area where there was an acute need for new developments. Rather than focus all their efforts on developing new drug compounds, he thought, pharmaceutical researchers should devise new drug delivery systems for those compounds already available. Dr. Zaffaroni recognized that traditional methods of delivering drugs—by oral administration of tablets or by intravenous injections—are very inefficient in two respects. First, the drug is delivered throughout the body, although the disorder being treated might be localized within one organ. Second, the concentration of the drug reaching the "target" site undergoes large fluctuations with time. Shortly after the drug is ingested or injected, it reaches a maximum concentration in the bloodstream. Undesirable side-effects may appear unless the dosage is restricted. But then, as the drug is metabolized, its concentrations fall well below the level needed for optimal therapeutic action. A steady concentration of the drug in the blood stream can only be maintained by continuous intravenous infusion, which must be

monitored and adjusted by trained nurses in a hospital environment. Zaffaroni felt that simple drug delivery systems could be developed so that drugs could be applied to specific sites in the body or released into the bloodstream at a uniform rate. However, he could not put his ideas into practice at Syntex, which had committed its limited resources to developing synthetic hormones.

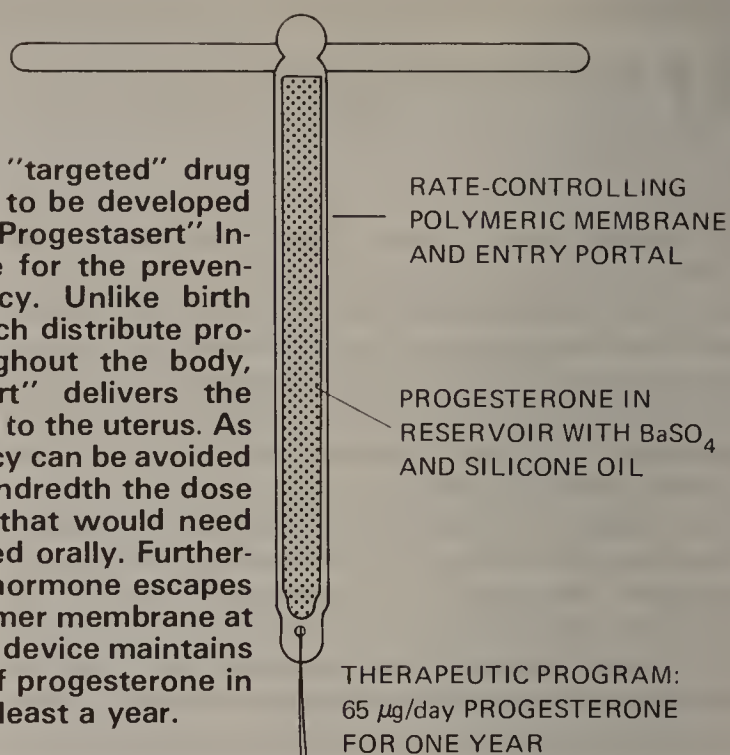
Zaffaroni left Syntex to form Alza Corporation in 1968, gambling his scientific reputation and a small personal fortune. At the same time, although Zaffaroni had not by then done any research for some years, his scientific knowledge and accomplishments were invaluable in attracting first-rate scientists from a wide range of specializations. He needed a team of specialists (and outside consultants) who would collectively provide a broad range of expertise in pharmacology, advanced membrane technology and biomedical engineering. His research staff drew their experience from such diverse areas as photographic film technology, plastics processing, water desalination, secondary oil recovery and freeze drying of orange juice. His marketing experience must have been invaluable in securing the confidence of investors and business associates.

Very likely, an improved system to administer birth-control hormones was the first application that Zaffaroni envisaged (having participated himself in the analysis and testing of contraceptive steroid hormones). By the late 1960's, it had been recognized that the high doses of progesterone delivered by the birth control pill subjected women to an increased risk of stroke and other medical hazards. Only a small fraction of the progesterone actually reached the reproductive organs to exert its desired effect (inhibition of ovulation): the remainder circulated throughout the body, eventually being metabolized or excreted. Alza set out to make a device that would release progesterone at a continuous rate within the uterus itself. The end-product of their research is a device (trademarked "Progestasert") containing a hormone solution within a permeable polymeric material. It is inserted into the uterus like a conventional Interuterine Device (whose contraceptive effect is due to irritation of the uterus wall), and slowly releases progesterone. The total amount of progesterone delivered during its one-year effective lifetime is only about one-hundredth the dose that would need to be taken orally to prevent pregnancy during the same time period. A further advantage is that it reduces menstrual blood loss by about 50% (in contrast to conventional Intrauterine Devices, which increase menstrual blood loss). Alza began manufacture and marketing of their "Progestasert" product in 1980, and are continuing clinical tests to document its efficacy for periods longer than the 12 months for which it is presently recommended.

A similar "targeted" drug delivery system developed by Alza is used for treating glaucoma (a disorder which, if left untreated, leads to blindness).



One of the first "targeted" drug delivery systems to be developed by Alza is their "Progestasert" Intrauterine Device for the prevention of pregnancy. Unlike birth control pills, which distribute progesterone throughout the body, the "Progestasert" delivers the hormone directly to the uterus. As a result, pregnancy can be avoided with only one-hundredth the dose of progesterone that would need to be administered orally. Furthermore, since the hormone escapes through the polymer membrane at a steady rate, the device maintains a uniform level of progesterone in the uterus for at least a year.



It replaces pilocarpine eyedrops, which need to be applied to the eye several times each day to lower the fluid pressure within the eyeball. Alza's "Ocusert" system contains the drug within a thin multi-layered polymer film which is worn under the eyelid. It delivers pilocarpine at a controlled rate for one week—making treatment more convenient, reducing the amount of applied drug to about one-tenth that administered with eyedrops, and lessening visual side-effects.

For nearly all drugs that are now administered orally or by injection, a system that would deliver the drug at a uniform rate would provide a major advantage to clinicians and pharmaceutical researchers. The dose at which a drug is applied is extremely important, since the effect of many drugs is *not* simply proportional to its concentration in the bloodstream. Not only does the concentration determine the drug's effectiveness and side-effects, but it can alter the very nature of its effect. Perhaps the most familiar example is alcohol, which acts as a stimulant at low doses (apparently by suppressing inhibitions) but exerts a strong depressant action at high doses. It is therefore extremely difficult for biomedical researchers to accurately assess the biological effect of a substance unless its concentration can be maintained at a steady level.

To this end, Alza researchers have developed an ingenious device, the mini-osmotic pump. This tiny capsule can be filled by the researcher with any test drug, and then surgically implanted in a mouse or other test animal. Once implanted, it delivers the drug at a steady, precisely-controlled rate for one or two weeks. Osmotic pumps are increasingly being used to help screen potential drug compounds, and are being utilized in a wide range of biomedical studies.

For oral administration of drugs to human patients, Alza has developed their "Oros" system, in which a tablet of solid drug is contained within a water-permeable polymer membrane. The system looks like an ordinary pill, but it does not dissolve in the digestive tract. Instead, water diffuses at a con-

stant rate through the permeable membrane, dissolves the drug, and forces the drug solution out of a tiny orifice in the membrane coating. The capsule can be designed to deliver medication at a controlled rate throughout its 24-hour passage through the gastrointestinal tract (by comparison, even conventional time-release tablets deliver most of their drug content within 2 - 3 hours). After passing through the intestine, the empty capsule is excreted intact.

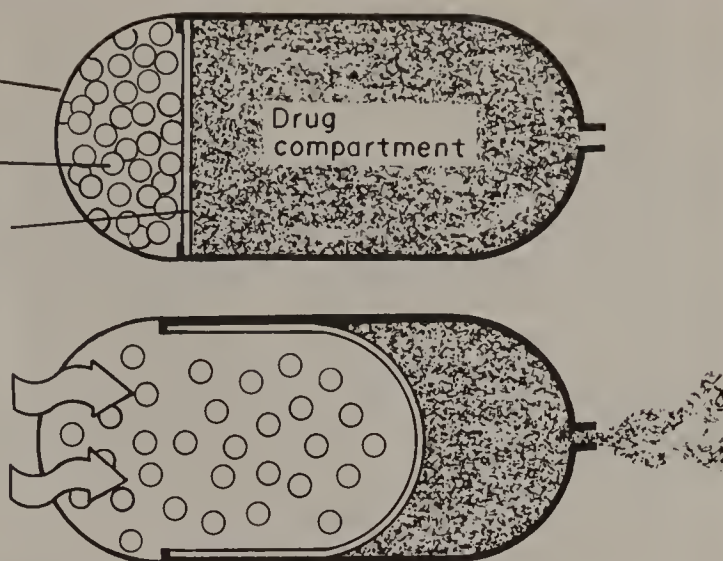
The Oros system can be adapted for most medicines taken orally. The tablets can be produced and packaged with conventional pharmaceutical equipment. Only the formation of the delivery orifice requires a new technology, laser drilling (a technique borrowed from the microelectronics industry). Several pharmaceutical companies have begun clinical trials using the Oros delivery system with their own drug formulations. Alza collaborates with these client companies to develop, test, register and manufacture continuous-release drug products. Usually, the client company pays the cost of development and testing, and retains marketing rights to the products developed. In return for providing its technology and expertise, Alza will receive a royalty on sales of these products. The Oros system will probably be applied initially to those drugs that cause serious side-effects when taken as ordinary tablets, or that must be ingested at frequent intervals. The first continuous-release medicines are expected to be approved for sale in 1982 or 1983.

Alza's technical expertise is not necessarily limited to the application of drugs. Sugar is one example of a biologically-active substance of which large amounts are ingested for a small concentration to be maintained at the "target organ", the tongue. By chemically bonding molecules of sugar or an artificial sweetener to a bulky, inert macromolecule, it should be possible for researchers to develop substances that impart the sensation of sweetness without being absorbed from the gastrointestinal tract. Such synthetic sweeteners would be of value to diabetics and those on calorie-restricted diets. The same

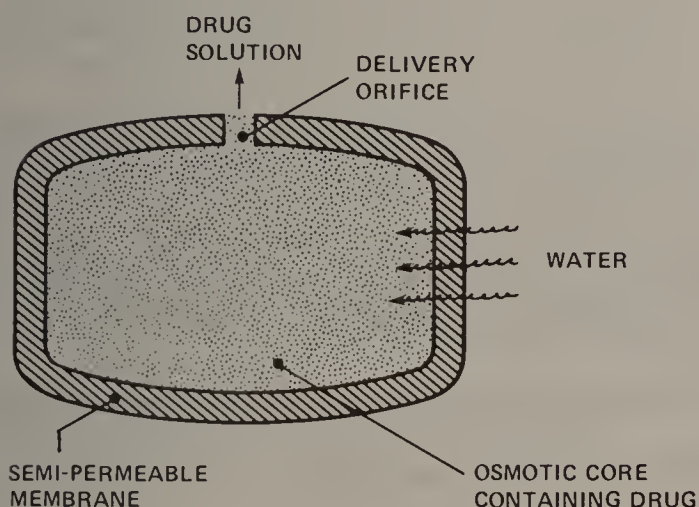
An ingenious device developed by Alza Corporation, the mini-osmotic pump, helps laboratory researchers to study the effects of biologically-active substances on test animals. When the tiny capsule is implanted in a laboratory animal, it delivers its drug content continuously—at a constant rate—over a period of one or two weeks. The device operates on the difference in salt concentration between the animal's dilute body fluids and the saturated solution inside the capsule's salt compartment.

An osmotic pressure develops across the semipermeable membrane separating the two solutions, driving water into the capsule through pores in the membrane.

Membrane (water-permeable)
Salt compartment
Elastic impermeable membrane



The influx of water causes the salt solution to swell in volume, but does not reduce its ionic concentration (since additional salt dissolves to keep the solution saturated). Water diffuses into the salt compartment at a constant rate, since salt concentrations on both sides of the membrane are held constant. As the salt solution expands, it pushes against an elastic membrane. The membrane distends into the drug compartment, squeezing the drug solution out through a narrow tube. The drug enters the surrounding animal tissues, from which it is soon absorbed.



For delivery of drugs to human patients, Alza has developed their "Oros" system for medicines taken by mouth. The medication is contained within a semi-permeable polymer. The tablet looks very much like an ordinary pill, although the polymer coating passes intact through the digestive system. Once the tablet has been swallowed, water permeates into the tablet through the polymer coating and dissolves the drug mixture. The concentration difference between the drug solution inside the tablet and the surrounding digestive fluids gives rise to an osmotic pressure. This causes a continuing migration of water into the tablet, and forces the drug solution out a narrow hole in the polymer coating. Thus, the drug can be released continuously throughout the tablet's 24-hour passage through the digestive system.

technology should also allow the development of food colourings and preservatives that are not absorbed into the bloodstream (and thus, should be more acceptable to those concerned about possible long-term deleterious effects of food additives).

Alza conducted initial laboratory tests to confirm the feasibility of producing non-digestible sweeteners, food colourings and preservatives. They then provided most of the investment capital needed to form a new company, called Dynapol—a second-generation spin-off from the steroid research at Syntex. In fact, Dr. Zaffaroni believes that founding such spin-off companies is the best way to foster innovation and provide a creative outlet for the scientists working in his own organization. Based on the technology developed at Alza, Dr. Zaffaroni hopes to spin-out new subsidiary companies at a rate of about one every two years.

Dr. Zaffaroni was not the only individual who applied the knowledge and experience acquired at Syntex to launch new commercial ventures. Dr. Carl Djerassi, who led the research team which developed

the contraceptive pill at Syntex, was ultimately to set up a new company, named Zoecon. It was partly funded by Syntex, but was operated independently. This venture originated with a postdoctoral research project undertaken at Syntex Laboratories by Dr. John Siddell. The initial aim of this project was to synthesize a steroid compound which caused some insect species to molt (and thus, might be used to artificially induce molting and prevent normal growth of the insect). No doubt, this project was selected because the chemical structure of the compound was similar to the human steroid hormones with which Syntex chemists already had extensive experience. Although efforts to synthesize this new steroid compound were eventually abandoned, this work convinced Dr. Djerassi that other insect hormones could be utilized to eradicate insect pests by controlling their growth, metamorphosis or reproduction.

Dr. Djerassi formed the new company to study insect hormones, synthesize compounds that mimic their action, and manufacture new types of com-

mercial pesticides. By 1971, they had synthesized a relatively stable compound which mimicked the activity of natural insect juvenile hormone, thereby disrupting the metamorphosis between insect larva and adult. Insects that had been exposed to the synthetic hormone were not able to function or reproduce normally. It was clear that infestations could be eradicated by spraying the hormone at an appropriate period in the insect pests' life-cycle. The compound exhibited virtually no toxicity to test animals (even the highest dose that could be administered did not kill the animals). Furthermore, unlike conventional pesticides which kill both insect pests and beneficial predator insects, the insect hormone was specific against particular species.

Despite the low toxicity and specific activity of insect juvenile hormones, Zoecon had to conduct a lengthy programme of safety and environmental testing to meet the requirements of government regulatory agencies before their new product could be marketed. The company's initial expectations that insect hormones could be registered in significantly less time than conventional organochlorine and organophosphorus insecticides, turned out to be entirely unfounded. In fact, Zoecon now expects that the products it is now developing will not be commercially available before 1988.

Regulatory approval has, however, been obtained for several insect hormones—especially those intended for non-food crops (such as mosquito control in swamplands, and to protect flowers grown by greenhouses and homeowners). But here, Zoecon has encountered a barrier of consumer ignorance. They found that consumers expect insect hormones to act in the same way as do conventional insecticides, and are reluctant to learn new application methods. One hormone kills embryos of aphids (a common pest in

garden plants and food crops), but takes several days to halt an infestation. During one field test, a farmer was surprised to see that his crops were still infested with aphids shortly after having been sprayed with anti-aphid hormone. Thinking the new product to be a failure, the farmer had his crop sprayed the following day with conventional insecticide. Quite clearly, an intensive educational programme will need to be undertaken by Zoecon to gain the confidence of consumers, in addition to the extensive testing programme required by regulatory agencies. Despite Zoecon's success in the research laboratory, the company's survival was threatened by financial and legal realities of the marketplace.

In spite of these difficulties, the company was able to achieve sufficient sales by 1976 to meet its expenses. Dr. Djerassi still believes that insect hormones will eventually capture 30 - 50% of the worldwide market for insecticides. However, being a pragmatist, Dr. Djerassi knows that a persistent uphill struggle must be maintained if this goal is to ever be achieved. As one Zoecon executive has admitted, it takes more than good science to make a commercial success. Zoecon was started as a means to pursue scientific objectives, but now, business practicalities and science go hand-in-hand. In order to get the large investment needed to finance further substantial research projects, the company utilized its reputation as an "environmental good guy" to attract a merger with a major multinational corporation. In this way, it may have sacrificed some of the very independence for which it had originally been formed. Perhaps there is already a bright innovative chemist working at Zoecon who is unable to develop his ideas, and is looking outwards for an untapped market and available capital to start his own commercial venture.

Microprocessor control of instruments alters the role of the chemical analyst

The application of microprocessors to chemical instrumentation has been absolutely phenomenal, as Dr. M. A. Ford (of Perkin-Elmer Limited) pointed out to a Royal Society Discussion Meeting*. Virtually all new chemical instruments are now microprocessor controlled, as compared with the situation only a few years ago, when none of Perkin-Elmer's instruments contained a microprocessor. At that time, some observers expected that the main use of microprocessors would be for very sophisticated research instruments, and not for relatively simple, widely-used spectrophotometers. But exactly the opposite situation has developed.

Microprocessors have become an integral part of optical and infrared spectrophotometers. Not only are they used for processing spectral data, but they are used to *control* instrument operation. On fluorescence instruments, for example, microprocessors can perform a preliminary scan of the spectrum to

select the best incident light wavelength, set a scan time that allows the desired resolution to be achieved, and scale the absorption or transmission data to clearly show fine spectral features. Some instruments can calibrate themselves, and indicate a fault if the calibration factor lies outside the usual range. This or other instrument failure can be relayed directly through a telephone line to the instrument service department.

Even more functions are performed by the microprocessor in those instruments now being developed. As one example, Dr. Ford pointed to the use of "soft keys" on instrument control panels. These allow the analyst to choose among a wide range of instrument programmes with only a few keys. Operating modes available to the analyst are presented on a video display screen. The analyst selects one of the operating modes, and presses the corresponding key located immediately below on the control panel. Then, another set of instructions is

displayed on the screen, corresponding to the same set of keys. Each key on the control panel can therefore provide a number of instructions for communicating the requirements of the analyst to the instrument's microprocessor. In this way, an instrument with an extremely simple keyboard can be programmed to perform a wide array of complex tasks. Such enhanced interaction between the chemical analyst and microprocessors in "intelligent instruments" was one of the main areas for further advancement that had been projected by one expert at last year's IUPAC Congress (see "Is there intelligent life in the laboratory" in *Chemistry International*, 1981, No. 6, pp. 21 - 22). In his lecture "Beyond mere automation", Dr. C. G. Enke had anticipated that electronic monitoring and control systems would continue to take on routine tasks now performed by human operators. The main role of the analyst in the future, he implied, would be to communicate to his instruments the type of information being sought for each sample.

Although microprocessor control is already being utilized in nearly all commercial instruments, its application in university-built research instruments is far from universal. That is not surprising, and not likely to change, in light of the extensive amount of programming

time required to achieve the full potential of microprocessor control. Developing the software for one instrument, Dr. Ford recounted from his own experience, took 9¼ man-years of effort and cost about \$500 000. For development of any new spectrometer to be economically viable, demand for the instrument must be substantial (with anticipated sales of at least several hundred instruments). Software now accounts for about 30% the development cost of a new instrument, and Dr. Ford expected this to rise to 50%. This does not necessarily mean that new instruments will become more expensive. In a few cases, the application of microprocessors has allowed simpler mechanical linkages for manipulating diffraction gratings and prisms, and has actually reduced the cost of an instrument. The main economic advantage of microprocessor-controlled instruments, however, is that they can reduce the *cost per analysis*. They can provide high-quality results more rapidly, with far less human supervision, than conventional manually-controlled instruments.

**The Discussion Meeting "New Techniques in Optical and Infrared Spectroscopy" was organized by the Royal Society, and held in London on 21 - 22 April 1982.*

LETTERS

Cheap, home-made polarograph provides good analysis results

I read with interest the article "Home-made chemical instruments upgrade laboratory training at low cost" (published in *Chemistry International*, No. 2, 1982). Besides pH and conductometric measurements that can be made with simple instruments, it is also possible to build very simple instrumentation for DC polarography. A simple polarograph can be made using two opamps (if necessary, they can be battery operated). The only component which is moderately expensive is a chart recorder, which is very useful to provide an automatic record of the variation of current versus voltage (a polarogram).

Even a simple DC polarograph can provide good results in a very broad spectrum of analytical problems. Trace levels of heavy metals can be estimated at sub-ppm concentrations in water, in air (as aerosols), as well as in biological and other materials. Polarography is not limited to the determination of metals. Natural products, drugs, pesticides and other organic compounds (including, for example, emissions into the atmosphere from factories) can be measured. I think that polarography could play a very important role in educational institutions, industrial laboratories and environmental protection

laboratories, especially in developing countries where sophisticated and expensive instruments are not available or practical. The only limitation of polarography is that it requires a highly skilled analyst (except for routine analysis). By including polarography and voltammetry into chemical education programmes, as was done in the past, an adequate supply of trained analysts should become available.

By the way, I believe that operational amplifiers could form the basis for a modular approach to teach students about chemical instrumentation (see *Operational Amplifiers in Chemical Instrumentation*, by R. Kalvoda, Halsted Press - John Wiley, New York, 1975). Many different types of measurements and analytical methods can be performed with a single instrument, using a kit with modules containing operational amplifiers. This concept offers several advantages, including (1) a better understanding by students of the principles involved in chemical measurements, (2) creating the possibility of constructing home-made apparatus, (3) allowing the design of instruments for construction in the electronic lab or workshop, and (4) offering low-cost instrumentation for chemical education and laboratory use.

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Commission on Electroanalytical Chemistry

Trace analysis poses unsuspected pitfalls to the complacent analytical chemist

The advent of extremely sensitive spectroscopic instruments and analytical techniques has allowed chemists to measure smaller and smaller concentrations of sample constituents, reaching well below the part-per-million level to the realm of part-per-billion concentrations. It has, of course, been assumed that measurements obtained with these instruments by experienced analysts are accurate and reliable. For many years, this assumption remained unchallenged, since "correct" values of trace constituents in seawater, minerals and animal tissues were rarely known.

One way that an analyst can assess the accuracy of his experimental technique is to compare his results with those obtained by different laboratories, using different methods of analysis. However, many analytical laboratories are reluctant to cooperate in this way. As Dr. William Horwitz (of the US Food and Drug Administration) points out in a recent paper*, every laboratory tends to regard itself as the centre of the analytical universe, barely perceiving the existence of other laboratories. In some cases, however, collaborative studies have been undertaken. Identical samples were distributed to various laboratories throughout the world and the results compared. After analyzing data from about 100 such collaborative studies, Dr. Horwitz concluded that occasional anomalous results (or "outliers") are obtained by even the most skilled analyst using the best equipment. In his paper "The Problems of Utilizing Trace Analysis in Regulatory Analytical Chemistry", Dr. Horwitz states that there appears to be an irreducible fraction of outliers in all analytical studies, regardless of the skill of the analyst and the quality of the instruments. The analyst is usually blissfully unaware of his production of these anomalous results.

Even more disturbing, experienced analysts have sometimes reported results that were consistent with values obtained by other leading laboratories, only to find years later that their results simply reflected the amount of contamination introduced during the analysis. In many such cases, the reported concentrations of trace constituents were far too high—often by a factor of tens or hundreds.

What becomes clear from this experience is that trace analysis is not simply an extension of traditional analysis methods to concentrations that are a thousand or million times less. With conventional titrimetric or gravimetric analysis methods, the analyst is measuring a component comprising a substantial fraction of the sample, usually well in excess of 0.1%. If the compound

being analyzed is made to undergo some reaction, such as being neutralized or converted to a coloured intermediate, the reaction proceeds to completion according to a well-defined equation. The analyte can be kept entirely within one phase, so that none is lost when a solution is transferred to another vessel. Thus, the analysis method can be designed so that all reaction equilibrium constants and partition coefficients favour quantitative conversion and recovery of the analyte.

Results obtained by different laboratories using conventional macro analysis generally agree within about 2% of the mean value. Systematic and random errors are much less than the actual quantity being measured, and thus, experimental uncertainty does not seriously affect the usefulness of the result in evaluating the sample's economic value, health hazard or conformation with government regulations.

These conditions do not apply when the analyst is measuring trace amounts of material. For one thing, contamination is a serious, ever-present threat. Concentrations of the analyte in the laboratory environment may far exceed the part-per-billion levels in the sample. Trace elements or other substances maybe slowly leached into the sample solution from glass or plastic containers normally used for sample storage. Contamination may also originate from metal sampling implements, be deposited by airborne dust, or transferred in the analyst's sweat or dandruff. Lint, dust, flaking paint, corroded metal surfaces and exhaust fumes are rich sources of trace elements. In fact, as Dr. K. A. Hunter points out†, "the usual chemical laboratory is a regular cornucopia of airborne and surface contamination." He explains that most work on trace element analysis of the ocean is now carried out in specialized clean laboratories. Materials used in construction of the laboratory are rigidly controlled, and special attention is paid to analytical procedures and laboratory clothing. These precautions, Dr. Hunter feels, are the *minimum* necessary to obtain reliable analytical results for trace elements in the environment. They do not guarantee good results. The analyst still has the responsibility to assess the possibility of sample contamination. In fact, considerably more time and effort might be spent analyzing "blank" solutions, reference standards or "spiked" samples than is actually spent analyzing the sample itself.

Dr. Hunter feels that reliable measurements of trace elements have only been made in the last few years, allowing the first real progress to

be made in understanding the behaviour of these elements in the environment. He points to "the alarming fact that most of our present understanding of man's effect on the marine environment is based on meaningless information". As an example, he points to measurements of copper concentration in sea water. Until about ten years ago, copper concentrations reported by various investigators were scattered over the range of 1 - 10 ppb. Very recent results show much greater consistency, and have converged to a narrow range of concentration at about 0.1 ppb. Similarly, presently-accepted concentrations of lead, nickel, zinc, mercury, selenium, manganese and chromium in sea water are at least a factor of 10 lower than previous published results.

Dr. Horwitz recounts the same type of experience with clinical chemical measurements. The analysis of chromium in the blood or blood plasma of healthy individuals would seem to be a straightforward problem (chromium plays an important role in the metabolism of glucose), but reliable measurements have proven remarkably elusive. As measurement techniques have become more refined and analysts more aware of the possibility of contamination, values reported for the chromium content of human blood have declined steadily during the last 25 years. Presently-accepted values of about one ppb are *1000 times* less than earlier measurements had indicated.

But that does not prove that recent results can be regarded with complete confidence.

Earlier investigators were surely convinced of the accuracy of *their* results, Dr. Horwitz emphasized. These analysts made their measurements using the most modern, sensitive and reliable procedures then available. Almost every one had obtained a linear calibration curve, and most checked their calibration by spiking their samples with known amounts of chromium. We cannot assume, Dr. Horwitz argued, that because recently-reported values are lower than those obtained by previous measurements, they are necessarily more accurate. Lower values might merely reflect the loss of material by adsorption onto the surface of glass containers used in the collection, storage or analysis of sample solutions. Even now, it is still not possible to make meaningful comparisons of chromium blood levels measured by laboratories in different countries. The variation in results might reflect real biological variability (perhaps, due to different diet or environmental conditions), or might result from random or systematic errors of measurement.

Dr. Horwitz made other remarkable observations while investigating the results of interlaboratory collaborative studies. He found that the reproducibility of results obtained by different laboratories did not depend on the nature of the analyte, or the analytical techniques that were used. The consistency of results seemed to depend only on the concentrations being measured. When conventional macro analyses were performed on identical samples (typically, containing several percent

Reliability of trace element analysis is prime concern of IUPAC Toxicology Commission

Obtaining reliable analytical results is of paramount importance in clinical chemistry. An incorrect value can mislead the physician in diagnosing a medical disorder or reduce the effectiveness of treatment. For this reason, clinical chemists have always appreciated the need to verify the precision and accuracy of their results and to maintain on-going quality control programmes. Indeed, since the IUPAC Commission on Toxicology was established in 1973, the reliability of analytical measurements of trace elements has been a focal point of the Commission's activities. The Commission has been a leading proponent of collaborative studies designed to compare analytical results obtained by different laboratories specializing in trace metal analysis. Based on the information gleaned from their own collaborative studies, in which identical samples were distributed to various laboratories throughout the world, the Commission was able to establish a reliable Reference Method for the analysis of nickel in blood and urine. The Commission also participated in an international conference (sponsored jointly by IUPAC's Analytical, Applied and Clinical Chemistry Divisions) to discuss the design and undertaking of

collaborative analytical studies. Proceedings of that conference have recently been published as a 170-page softcover volume, *Collaborative Interlaboratory Studies in Chemical Analysis* (Edited by Drs. T. S. West and H. Egan, Pergamon Press, 1982).

Most recently, the IUPAC Commission on Toxicology has been working with the Commission of the European Communities to organize a workshop to consider the state-of-the-art of analytical methods for measuring cadmium concentrations in blood, urine and kidney tissue. The Workshop, entitled "Biological Indicators of Cadmium Exposure: Diagnostic and Analytical Reliability", will review reference methods and materials for cadmium analysis, and quality control of analytical results. The Workshop organizers also plan a round-table discussion to consider screening and surveillance methods, standardized test procedures, use of control materials, and conduct of quality control programmes at the national and international levels. The proceedings of the Workshop, including scientific papers and discussion, will be published under the auspices of the Commission of the European Communities, Luxembourg.

analyte), different laboratories were able to obtain results with a coefficient-of-variation in the range of 2%. However, interlaboratory measurements of pesticides at the part-per-million level had a coefficient-of-variation of 15%. The result obtained by averaging these values generally differed from the "correct" value by 30%. Of course, analytical results obtained in the same laboratory are generally more reproducible, but probably not more accurate. In fact, the smaller coefficient-of-variation of results obtained in one laboratory might conceal large reproducible errors, and impart a false sense of confidence in the analytical results. Dr. Horwitz concludes that any one measurement at the part-per-million level can be expected to have an error of 50% its value. A concentration measurement at the part-per-billion level can be expected to be even less accurate—only within a factor of two of the actual value.

Such poor accuracy may seem wholly unacceptable to chemists who are used to reporting results to three or four significant figures, but an order-of-magnitude result may be sufficiently accurate for many studies of trace constituents. Obtaining consistent results is often more important than knowing the absolute concentration of the analyte. Perhaps it does not matter very much, Dr. Horwitz suggests, whether a given blood sample contains one or two parts-per-billion of chromium. The chemist might only need to determine whether that sample contains a higher or lower concentration than another sample.

Dr. Hunter pointed to recent studies of concentrations of biological nutrients in the ocean. The concentration of soluble phosphate, for example, spans a large range, increasing from immeasurably small values at the ocean surface to a peak concentration of about 3

parts-per-billion at a depth of one kilometre. This "depth profile" is evidently due to very rapid assimilation of this nutrient by organisms living at the ocean surface, and their bacterial decay as the organisms die and sink towards the ocean bottom. The depth at which the peak phosphorus concentration occurs provides information about the rate of bacterial decay, and the rate at which nutrients are returned to the surface by diffusion or upwelling. A similar depth profile for cadmium shows that it too is incorporated into the soft tissues of surface organisms. However, the distribution of silica is very different, with the maximum concentration occurring at much greater depth. Marine organisms incorporate silica into their exoskeletons, which are decomposed more slowly. The fact that zinc has a depth profile similar to silica shows that it is also incorporated into the skeletal parts of organisms living near the ocean surface. For such studies, the absolute value of the concentration is not important. What is needed to learn more of the mechanisms of nutrient transport in the ocean is consistent, reliable test results—and that requires meticulous care and constant vigilance by the analytical chemist.

**The Problems of Utilizing Trace Analysis in Regulatory Analytical Chemistry" was a lecture presented by Dr. William Horwitz to the Analytical Chemistry Division of the Royal Australian Chemical Institute, and was published in Chemistry in Australia, February 1982.*

† "Marine Geochemistry of Trace Elements: a perspective" by Dr. K. A. Hunter, published in Chemistry in New Zealand, April 1982.

Removal of CO, NO_x and SO₂ from atmosphere hinges on OH radicals, produced from ozone

Concern about the destruction of "the ozone layer" and the rising level of carbon dioxide in the atmosphere has focused a great deal of attention on the chemistry of the atmosphere. Initial studies investigating these two questions disclosed how remarkably little was known about the sources and ultimate fate of various gases in the atmosphere. In order to clarify our basic understanding of chemical processes occurring in the atmosphere, a series of projects was undertaken by the Scientific Committee on Problems of the Environment (SCOPE, a committee of the International Council of Scientific Unions), attempting to explain the cycles whereby compounds of carbon, nitrogen,

phosphorus and sulfur are generated and destroyed.

The outlook of the SCOPE committee altered as new experimental data became available and more refined mathematical models were developed. From the considerable mass of information gathered during the last 7 - 8 years, a remarkable new perspective began to emerge at an international workshop held in May 1981. The participants confirmed that ozone plays an extremely important role in the chemical reactions occurring in the upper atmosphere, and perhaps more than anyone had expected, exerts a very great influence on reactions occurring at low altitudes. In par-

ticular, photochemical decomposition of ozone produces hydroxyl radicals which, despite their extremely low concentration, play a fundamental role in chemical reactions in the lower atmosphere. Hydroxyl radicals catalyze the oxidation of carbon monoxide, methane and other hydrocarbons; oxidize nitric oxide (to nitrate); and convert sulfur compounds to sulfate. The radical links the reactions of carbon, nitrogen and sulfur compounds so that these "cycles" are intimately coupled. The many photochemical interactions between the carbon, nitrogen and sulfur cycles, brought about by OH radicals, invalidates the previously-accepted notion that these cycles can be studied independently of one another.

Although it exerts such enormous effect on the atmosphere and living organisms on the surface of the Earth, the total amount of ozone in the atmosphere is minute; the same number of molecules would comprise a layer only 3 mm thick at standard temperature and pressure. Ozone is produced by the recombination of O_2 molecules with oxygen atoms (formed by fragmentation of O_2 molecules which have absorbed far-ultraviolet radiation). The important ecological function performed by atmospheric ozone—now widely recognized—is that it absorbs virtually all ultraviolet radiation with wavelengths less than 300 nm, and shields the Earth's surface from *most* ultraviolet radiation with wavelengths above 300 nm. The intensity of this radiation reaching the Earth's surface is determined by the total concentration of ozone in the atmosphere.

About nine-tenths the total ozone content of the atmosphere is contained in the upper atmosphere, above an altitude of 10 kilometres. Once it reaches the lower atmosphere, ozone undergoes photodecomposition and reaction with water vapour, producing hydroxyl radicals (OH). This radical, although present at extremely low concentration (less than one radical in 10^{13} molecules), exerts a powerful influence on the photochemical reactions taking place in the lower atmosphere. Most important, OH catalyzes the oxidation of carbon monoxide and methane, but it also induces reactions of nitrogen oxides, sulfur dioxide, hydrogen sulfide, dimethyl sulfide and methanethiol, and volatile natural organic compounds (notably isoprene and terpenes, exuded by trees).

Hydroxyl radicals exert such a potent effect

on atmospheric chemistry because they initiate chain reactions. For each OH radical that initially reacts with a molecule present in the air, thousands of product molecules can be produced. In fact, the hydroxyl radical is ultimately regenerated by the chain reaction. Sometimes, other radicals must also be present for the chain reaction to propagate. For example, OH radicals *and* oxygen atoms are necessary to catalyze the reaction between carbon monoxide and oxygen. This important reaction, which generates carbon dioxide and ozone, occurs only when nitrogen dioxide is present in the atmosphere, acting as a source of oxygen atoms (NO_2 decomposes when it absorbs near-UV radiation). When nitrogen oxides are present at very low concentrations, ozone is not produced as fast as it is destroyed by a competing chain reaction (in which ozone reacts with carbon monoxide).

For this reason, natural and man-made emissions of carbon monoxide, methane and hydrocarbons may sometimes be oxidized without any ozone being formed. Indeed, it appears that no ozone is produced in the lower atmosphere of the Tropics, where the relatively low level of industrial activity leads to a virtual absence of nitrogen oxides in the atmosphere. However, the expanding population and industrial base of tropical countries and the burning of biomass (as tropical rainforests are felled) could alter the global distribution of ozone in the atmosphere.

Nitrogen and sulfur oxides are released to the atmosphere in the exhaust gases of factories, smelters, high-temperature furnaces and vehicle engines (nitrogen compounds are also released to the atmosphere through intensive application of synthetic fertilizer). About the same total quantity of nitrogen and sulfur oxides are released by natural sources spread across the Earth's surface. But unlike diffuse natural exhalations of these pollutants, emissions from large industrial and urban centres produce high local concentrations. Not only are the concentrations of nitrogen and sulfur oxides much higher, but the relative amounts of atmospheric constituents varies considerably from the composition of "clean" air. It is reasonable to expect that the atmospheric chemistry occurring near industrial and urban centres might be very different from those processes occurring in the natural environment.

Detector tubes allow simple, low-cost analysis of gases and vapours

Monitoring levels of chemical vapours has become an important aspect of laboratory and industrial safety. As long-term exposure to chemicals gains recognition as a major occupational hazard, efforts are being made in many institutions to measure trace concentrations of contaminants and to monitor cumulative worker exposure. In the laboratory environment, where many toxic compounds may be handled at various times, specialized instruments for monitoring concentrations of one particular vapour are of little value. A flexible air monitoring system is required, able to provide rapid or long-term concentration measurements on a wide range of compounds that may be used in the laboratory.

Detector tubes are one of the most widely used means of measuring worker exposure to toxic vapours. They are also being adapted to solve specialized analytical problems. In fact, almost any chemical analysis involving the quantitative liberation of gas (by reaction of the analyte) can be performed with detector tubes. Analysis of gas concentrations with detector tubes is simple, convenient and low in cost. The only equipment required is an air-sampling pump (which is relatively simple and inexpensive). A detector tube is used for each measurement, and then discarded. It contains in one self-contained unit all reagents needed for a gas analysis test. No time-consuming procedures are required to prepare the sample, assemble an apparatus, and prepare and standardize reagent solutions. Detector tubes offer a convenient, simple and accurate method to perform chemical analyses, without any major investment in equipment. Millions of tests are conducted with detector tubes each month in laboratories and chemical plants throughout the world. It has been suggested that detector tubes have become to the field of gas analysis what canned food has become in the field of nutrition.

by Dipl.-Ing. K. Lechnitz
Drägerwerk AG
Chairman, IUPAC Commission
on Atmospheric Environment

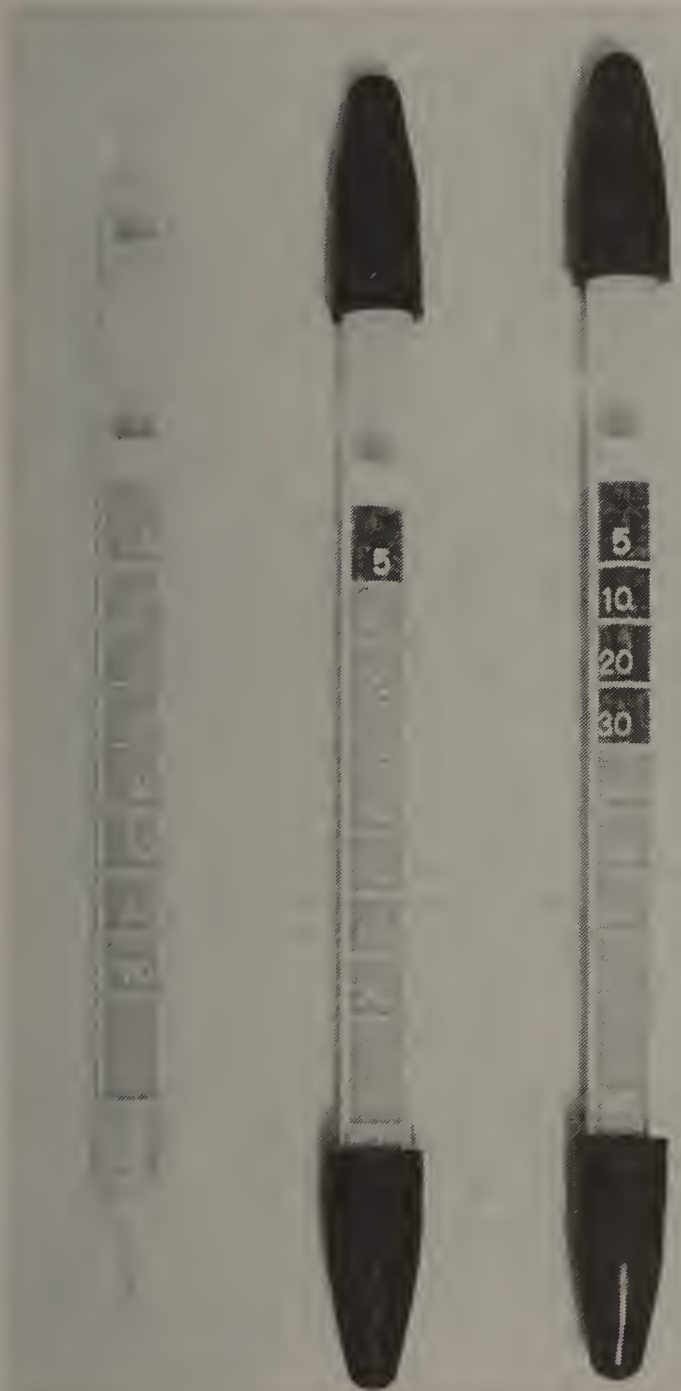
The detector tube is a hermetically-sealed glass tube containing a chemical reagent which produces a characteristic colour when it is exposed to the test vapour. Only a tiny amount of colour reagent is required to react with an air sample containing the toxic gas at a typical concentration of a few parts-per-million. The colour reagent, and other compounds which may be utilized to react with the gas, are therefore contained in a carrier material such as silica gel.

To conduct a test, the sealed ends of the detector tube are broken off, the tube is connected to the pump and a specific volume of air is drawn through the tube. Initially, the contaminant gas reacts with reagents at the front end of the indicator column. As the reagent there is consumed, the toxic gas permeates further down the column. The colour produced by the reaction also advances along the column as the gas sample is drawn through the tube.

At the conclusion of the air-sampling period the length of the coloured stain indicates the concentration of the toxic gas. An air-sampling measurement can be made in a few minutes, allowing the analyst to determine the concentration of toxic gas present at that particular time. Alternatively, the monitoring instrument can be carried on the belt of a laboratory worker to monitor his cumulative exposure during the day's work.

Approximately 300 different types of gases and vapours can be analyzed by detector tubes—such as acetone, ammonia, benzene, chlorine, formaldehyde, hydrazine, carbon dioxide, carbon monoxide, ozone, phosgene, sulfur dioxide and vinyl chloride to name a few. Each tube is designed to have maximum sensitivity and selectivity for the particular vapour to be measured. Some, such as the detector tube for hydrogen sulfide, contain only one reagent layer (which also serves as an indicator column). In this tube, the reagent is lead acetate impregnated on silica gel. Reaction of the lead salt with hydrogen sulfide produces brown-coloured lead sulfide. The length of the brown stain—and thus, the total amount of H_2S in the air sample—is read directly off

A colour change in the reagent - indicator column of a detector tube reveals the presence of the vapour being analyzed. The amount of vapour in the sample is indicated by the length of the discoloured section, which is read directly from a calibrated scale.



The reagent - indicator column is a uniform orange colour in the sealed, unused detector tube for ammonia, shown in the photograph above left. When the analyst is ready to make a measurement, the tips of the tube are broken off and a one-litre air sample is aspirated through the tube's reagent - indicator column. Ammonia vapour in the sample reacts with acid impregnated on the column's inert filling material. Complete neutralization of the acid (in that part of the indicator column) is disclosed by a colour change (from orange to blue) in an acid - base indicator. The total amount of acid that is neutralized—and thus, the length of the blue-coloured section of the column—is proportional to the content of ammonia in the air sample. The detector tube in the centre photograph indicates the presence of 5 ppm ammonia in the air sample, while the one on the right provides a reading of 30 ppm (*this, and subsequent photographs in this article, provided courtesy of the author*).

the calibrated scale of the indicator column.

Other detector tubes have two or more filling layers. The first layer is sometimes used to absorb compounds which interfere with measurements of the test gas, and thereby make the test more specific. The detector tube for hydrogen cyanide, for example, incorporates a pre-cleanse layer to remove highly acidic and basic gases. HCN, which is only very slightly acidic, passes through the pre-cleanse layer and reacts with HgCl_2 reagent, generating HCl. This product causes a colour change in an acid - base indicator contained in the reagent layer.

The tube for monitoring carbon monoxide relies on the production of iodine (imparting a brownish-green colour in the indicator layer) when CO is oxidized by iodine pentoxide in the presence of selenium dioxide and sulfuric acid. The reagent mixture is a powerful oxidizing agent, and many other organic vapours would also be oxidized. However, organic vapours do not reach the reagent - indicator column: they are adsorbed in the detector tube's pre-cleanse layer. Among all toxic organic vapours that may be present in an air sample, only carbon monoxide is not adsorbed. It passes unaffected to the reagent layer. A high concentration of organic vapours, which might cause possible interference with CO measurements, is indicated by a colour change in the pre-cleanse layer [imparted by reduction of a chromium (VI) reagent]. An additional pre-cleansing tube of activated charcoal can then be placed in the air-sampling line to ensure that all interfering hydrocarbons or halogenated hydrocarbons are absorbed.

The laboratory worker is usually not concerned specifically with the level of carbon monoxide, but would like to detect *any* toxic gas likely to be present—including CO. A general-purpose "poly-test" tube contains the same iodine pentoxide reagent - indicator column utilized in the CO detector tube, but it does not have a pre-cleanse layer to absorb organic vapours. The reagent - indicator column undergoes a colour change when the aspirated air sample contains toxic vapour. It responds to the presence of arsine, carbon disulfide, carbon monoxide, hydrogen sulfide, styrene, nitric oxide, toluene, trichloroethylene or xylenes at concentrations below the recommended exposure limit for working environments. The same tube also indicates the presence of benzene, petroleum distillates (motor fuel vapour), propane, butane and acetylene at levels that are an immediate health or fire hazard. Of course, a positive response by the polytest detector tube does not indicate which contaminants are present, or at what concentrations, but simply provides a general warning that one or more toxic gases are present in the air.

Some toxic vapours cannot be detected directly. These vapours can be monitored, nonetheless, by detector tubes incorporating a "conversion layer". The test vapour undergoes a preliminary reaction in the conversion layer, generating a product gas which *can* be detected by the following reagent - indicator layer. Among the many types of detector tubes that contain a conversion layer are those designed for monitoring perchlorethylene. Perchlorethylene vapour present in the air sample is initially oxidized by a permanganate salt in the conversion layer,

generating chlorine gas. This product is carried in the gas flow to the reagent - indicator layer, where a greyish-blue colour is produced by reaction of chlorine with N, N-diphenylbenzidine.

Detector tubes are generally expected to have a "shelf life" of two years. Although most tubes contain highly reactive reagents (as is required for rapid reaction with the vapour being analyzed), the reagents must not react with the silica gel carrier medium in which they are impregnated. Many tubes contain only a few hundred micrograms of active reagent. Even if only a small amount had reacted with the carrier medium (or with an impurity in the carrier medium) during storage, the detector tube would indicate an anomalously high concentration for the vapour being analyzed. The test vapour would advance a greater distance along the reagent column before "finding" the amount of reagent needed for complete reaction. Usually, filling mixtures can be prepared that remain unchanged during at least two years storage. For some test gases, however, sufficient stability can only be achieved when one reagent is stored in solution inside a sealed ampoule. The ampoule is broken open immediately before use by bending the flexible tube. The reagent solution then soaks into the indicator column.

Detector tubes are usually used to measure concentrations of gases at the part-per-million level. The sensitivity that can be achieved depends largely on the particular gas being analyzed. It is often possible to extend the sensitivity of the detector tube to lower concentration ranges by drawing a larger sample of air through the tube. In other applications, however, the analyst must measure relatively high gas concentrations. Detector tubes of low sensitivity are available for many gases. These contain a larger amount of reagent impregnated in the indicator column. For example, detector tubes for monitoring carbon dioxide span the concentration range from 0.01% by volume (100 ppm) up to 60%.

As with any other kind of analytical measurement technique, detector tubes are subject to analysis errors. The accuracy of a measurement depends primarily on the type of detector tube used, and the standard to which it is manufactured. Certification programmes to standardize the properties of detector tubes have been established by several institutions. Prominent among these is IUPAC, which published one of the first official standards on the properties of detector tubes (in 1974). Since then, IUPAC's Commission on Atmospheric Environment has prepared an updated report, *Performance Standard for Detector Tube Units*. They have also prepared a report, *Sampling Plan for Gases and Vapours in Working Areas*, which provides guidance for establishing a programme for monitoring toxic vapours. Both reports will be published in the IUPAC journal *Pure & Applied Chemistry* during the latter half of this year.

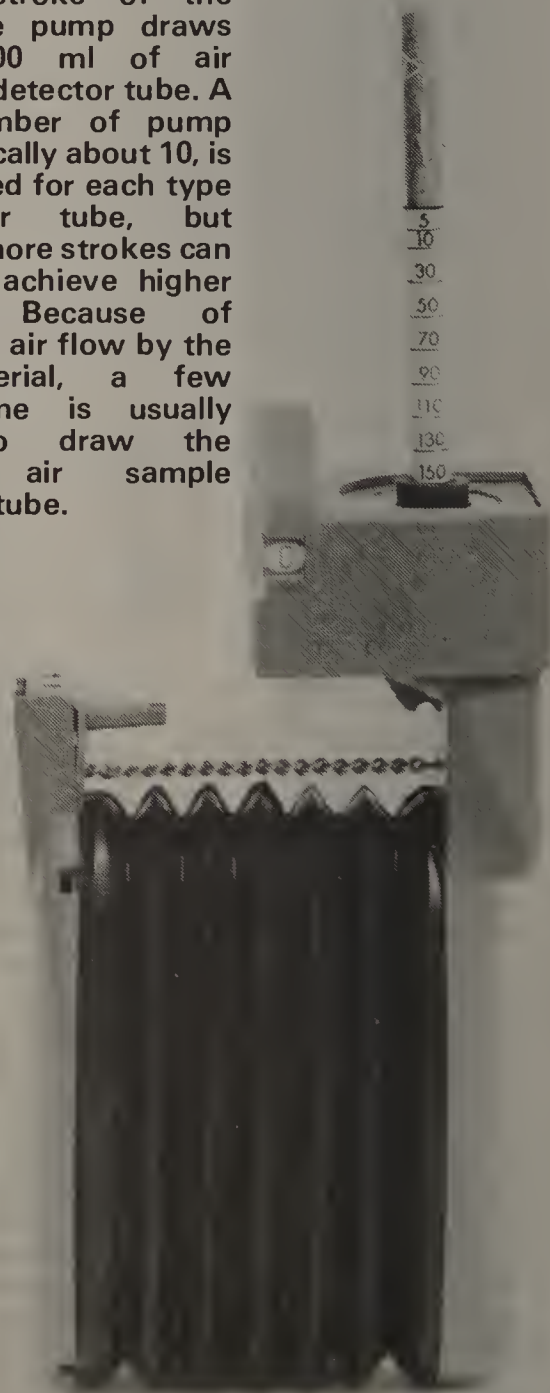
In their new performance standard, the Commission on Atmospheric Environment points out that the aspirating pump used for gas measurements with detector tubes must have the same flow characteristics as the pump used (by the manufacturer) to calibrate the tubes. Pumps made by different manufacturers may operate at different flow rates (even though they may draw the same total volume),

and should not be used interchangeably.

The IUPAC Commission distinguishes between two categories of detector tubes. Those designated as Class A must fulfill a higher standard of accuracy (providing a reading within 25% of the actual concentration). Class B detector tubes are intended for measurements in which less accuracy ($\pm 35\%$) is required. Each manufacturer must maintain a quality control system which allows these standards to be met. Quality control procedures and calibration methods employed by the manufacturers are made available to all users that request them.

The main application for detector tubes is the analysis of air in laboratories and manufacturing plants, but detector tubes can also be used for a wide range of analytical measurements. One area where they have been successfully employed is the determination of solvent residues in edible vegetable oils. Such oils are generally obtained by extracting crushed oilseeds (soya beans or sunflower seeds, for example) with a volatile solvent, like hexane. The

To make a rapid measurement of gas composition, a small hand-held bellows pump is used to draw air through the detector tube. For each stroke of the bellows, the pump draws precisely 100 ml of air through the detector tube. A specific number of pump strokes, typically about 10, is generally used for each type of detector tube, but sometimes more strokes can be used to achieve higher sensitivity. Because of resistance to air flow by the filling material, a few minutes time is usually required to draw the prescribed air sample through the tube.



hexane is later evaporated from the oil and recycled, but a small amount of residual hexane remains in the oil. The need for a rapid and simple method for determining the content of hexane in edible oils was therefore apparent. Various analysis methods had been used, but all were time-consuming or required sophisticated and expensive instruments. None was suitable for analysis of vegetable oils by untrained personnel.

Detector tubes meet these requirements, and are now being used to determine the hexane content of vegetable oils. Traces of solvent remaining in an oil sample are extracted by drawing a stream of air bubbles through the sample with a small hand-held bellows pump (which sucks in exactly 100 ml of air on each stroke). The air sample is expelled through a detector tube (after absorption of volatile oxidation products by a KOH-filled U-tube). Any hexane vapour in the air sample reacts with the detector tube's selenium dioxide - sulfuric acid reagent, changing the colour of the indicator column from yellow to brown. The length of the discoloured segment is proportional to the concentration of hexane in the oil. The simple apparatus is calibrated with test oils manufactured without any solvent, to which known quantities of hexane are added.

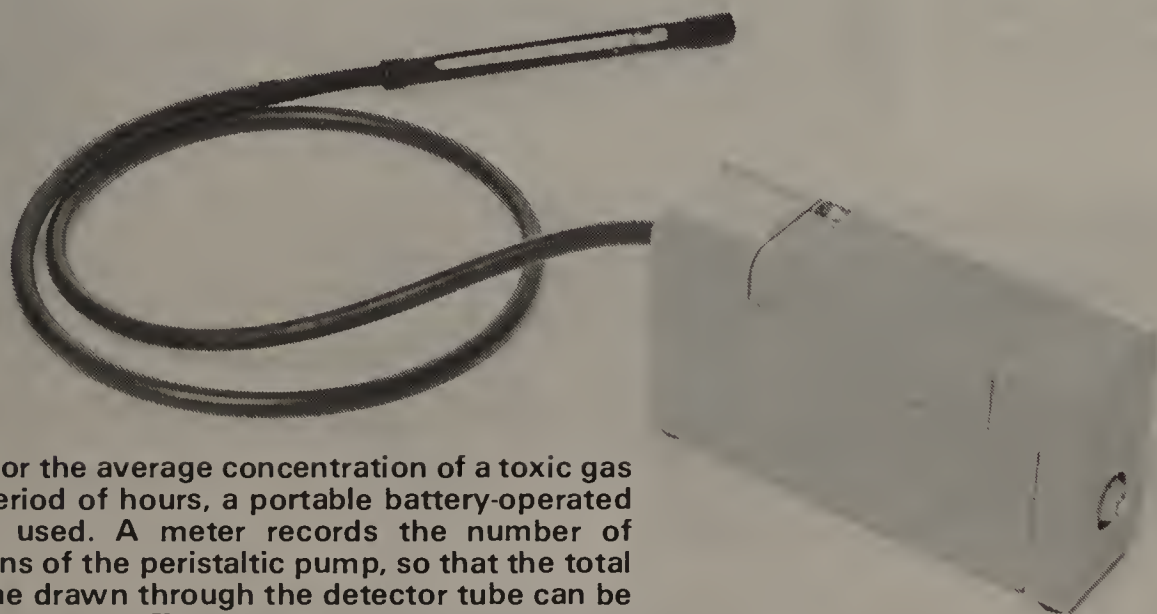
Detector tubes are also used to monitor the performance of activated charcoal filtering systems in removing solvent vapours from exhaust air dry-cleaning installations. The government of the Federal Republic of Germany requires that concentrations of trichlorethylene or perchlorethylene in the exhaust air of such establishments does not exceed 30 ppm. They recommend that the ventilation and filtering systems be checked periodically, and government inspectors use detector tubes to check that concentrations of dry-cleaning solvents lie within the prescribed limits.

Many other environmental-monitoring problems can be met by detector tubes. Since the carbon monoxide content of furnace exhaust provides a good indication of combustion efficiency, CO

measurements with detector tubes are used to monitor the operation of waste incinerators and check that they comply with air pollution regulations. In fact, detector tubes are especially well suited for the analysis of carbon monoxide, since no other simple analysis method offers high sensitivity and selectivity. The CO detector tube was the first to be developed (in 1919), and for many years, was the only detector tube in use.

Another application of detector tubes is the analysis of CO and other toxic gases evolved during combustion of polyurethane-ether foams used in airplane seats. Emission of poisonous fumes by burning plastic foam has been cited as a major cause of death in emergency aircraft landings. The decomposition products of polyurethane foams were recently examined with detector tubes, and the results confirmed by gas chromatography. Analysis results with the two techniques differed by no more than 10%, although only the detector tubes provided sufficient sensitivity for measurements of trace carbon monoxide levels. Detector tubes were also used to monitor the evolution of phosgene, hydrogen cyanide and hydrogen chloride. The study found that decomposition of one kilogram of plastic foam would release 20 grams of CO, 1.4 grams of HCN and 0.7 grams of HCl. The study is presently continuing, and will examine the effect of fire retardant additives on the composition of combustion gases.

The type of environmental problems for which detector tubes have been utilized include some very unusual situations. When natural gas was introduced in the cities of Amsterdam and Lübeck, underground pipes began to leak (as the seals dried out, since natural gas is much drier than the coke oven gas that had previously been used), causing hundreds of trees to sicken and die. The trees were being adversely affected by depletion of oxygen and accumulation of carbon dioxide in the soil as escaping natural gas was oxidized by bacteria. Bacterial oxidation of methane was found to occur so rapidly in the soil that natural gas could not be detected more than 5 metres from



To monitor the average concentration of a toxic gas over a period of hours, a portable battery-operated pump is used. A meter records the number of revolutions of the peristaltic pump, so that the total air volume drawn through the detector tube can be calculated exactly. The detector tube is mounted at the end of a flexible hose (as shown here), or can be mounted inside the pump case.

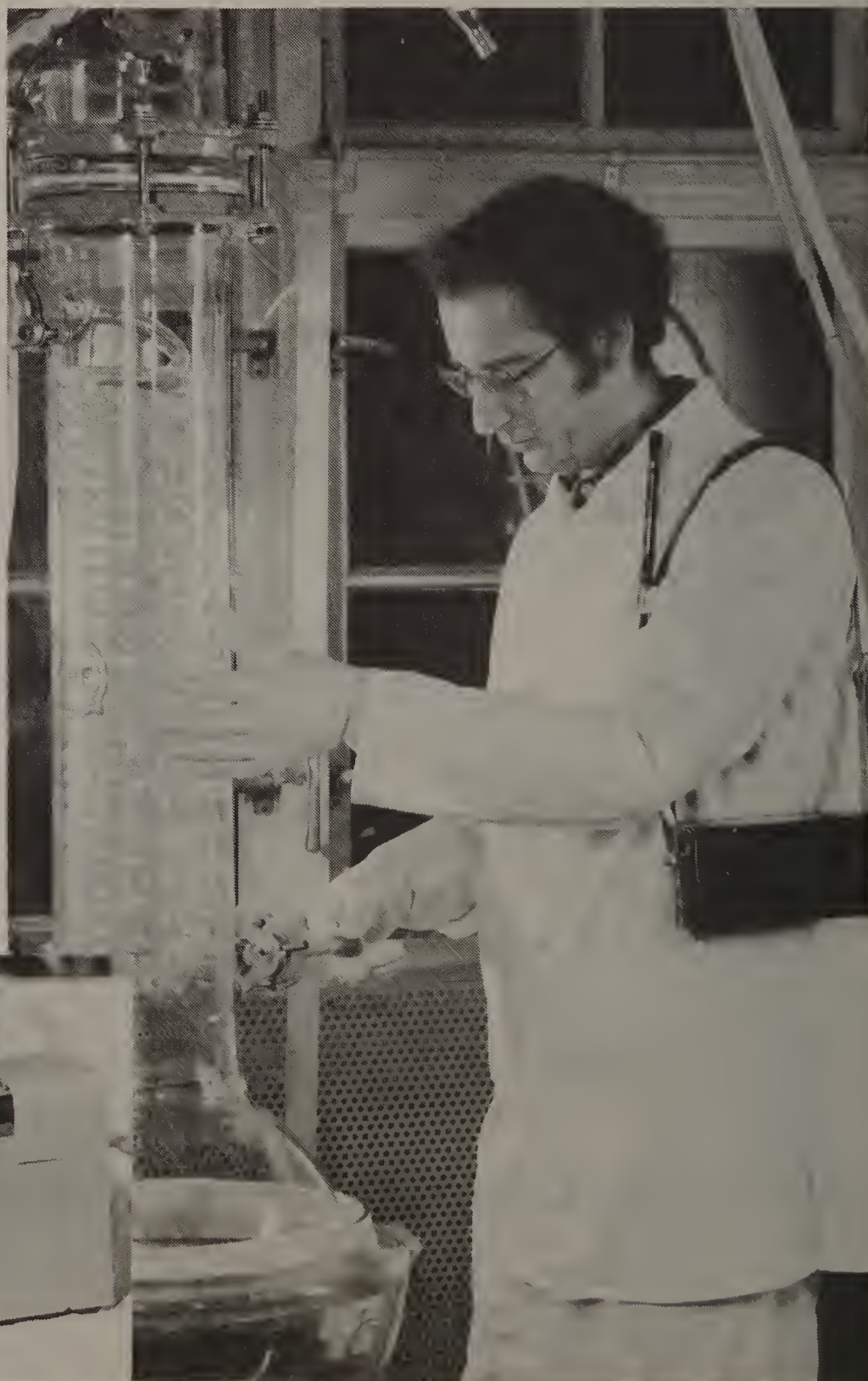
the point of leakage. Even after the leaks in a pipeline had been repaired, it would take 3 - 4 years for oxygen and carbon dioxide levels in the soil to be restored to normal levels. In order to prevent further destruction of trees, the Lübeck Parks and Gardens Department tried to artificially accelerate the regeneration process by pumping compressed air into the soil. To monitor the effectiveness of soil regeneration, they inserted probes into the soil and sampled oxygen and CO_2 levels with detector tubes. The treatment was found to be very successful, and the trees rapidly recovered from the effects of natural gas leakages. The Parks Department was able to plant new seedlings immediately to replace those trees that could not be saved.

Gas analysis with detector tubes is by no means limited to monitoring of environmental pollutants. Detector tubes have, for example, been used to help locate ore deposits by measuring the arsenic content

of soil and water. A very simple apparatus was developed to treat the sample with zinc and dilute sulfuric acid, converting any arsenic oxides or salts that were present to arsine gas (AsH_3). Arsine liberated by the reaction is analyzed by a detector tube. Results obtained by this method are remarkably consistent with analysis results obtained by a more laborious photometric procedure. The test is also extremely sensitive, and can detect arsine concentrations as low as 0.05 ppm.

A similar application of detector tubes is for the analysis of sulfides in drilling fluids during exploration for crude oil and natural gas. A high content of sulfides in seabed mud indicates that the drill may be approaching a deposit of gas or oil. Test results must be obtained rapidly, and an analysis method using detector tubes is recommended. The sample of drilling fluid is acidified, converting all sulfides to H_2S gas, which is analyzed by a detector tube.

For sampling the general laboratory atmosphere, a detector tube is mounted inside an automatic pump unit, which is left on the laboratory bench while experiments are being carried out nearby (as shown below). However, concentrations of toxic vapours may vary substantially from one point to another, especially near fume hoods, storage cabinets and chemical spills. To obtain an accurate indication of the amount of vapour actually inhaled by the laboratory worker, the pump unit should be carried by the worker, with the detector tube clipped near his face. Then, although the chemist might work at various locations in the laboratory (at which vapour concentrations may differ), the detector tube reading shows his cumulative exposure during the day.



IUPAC

Nearly all chemists have heard of IUPAC, but most have little knowledge of its role in the international scientific community. Even members of IUPAC Commissions are often not aware of the broad range of projects undertaken outside their own subject area. Of course, explaining what IUPAC does, and how it works, to the non-chemist is an especially daunting experience. The reason is that IUPAC is a complex organization, as it must be. It encompasses hundreds of chemical specialists, as well as participants from science academies, chemical societies, the chemical industry and educational institutions. It deals with all aspects of chemistry, which is perhaps the broadest of the natural sciences.

This article presents a brief overview of the type of international chemical problems on which IUPAC Commissions and Committees are focusing their efforts. It describes how the various Commissions function, how they co-ordinate their activities, and how IUPAC interacts with other international scientific bodies. It is, perhaps, the first concerted effort to explain, in a simple but relatively comprehensive way, three points that everyone should know about IUPAC:

What it is What it does How it works

By the beginning of the 20th century, it had already become apparent that there was a pressing need for international standardization of chemical names, symbols, terminology and standards. The need for chemists to communicate with colleagues in other countries was becoming more and more important. If time-consuming and expensive efforts were not to be duplicated, chemists had to know about new chemical compounds that were being made elsewhere, and had to communicate their own findings to other specialists throughout the world. At the same time, international trade in chemicals, food products and pharmaceuticals was also growing at a rapid pace. It was extremely important that manufacturers and users of chemical products were able to agree on the purity and composition of chemical products and raw materials.

IUPAC was founded in 1919 to provide a forum

for those countries involved with chemical research, production and use to standardize chemical nomenclature, terminology, atomic weights, and procedures for performing chemical tests and reporting data. Ever since, IUPAC has sought to establish uniform, universally-accepted nomenclature for chemical compounds, chemical terminology and symbols, reference materials and test methods.

Standardization of nomenclature and terminology is still a primary function of IUPAC, although it has also undertaken new activities. Prominent among these is IUPAC's CHEMRAWN programme, in which technical experts and world leaders are brought together to discuss the application of chemical research to world needs. The first CHEMRAWN conference, held in 1978, dealt with Future Sources of Organic Raw Materials. The conference "Prospectives and Recommendations" and



IUPAC officers present their proposals to the Council at the 1981 IUPAC General Assembly in Leuven, Belgium.

Proceedings volumes have become important reference sources for leaders in industry and government throughout the world. The second CHEMRAWN conference, to be held in December 1982, will deal with "Chemistry and World Food Supplies—the New Frontier". Plans are also progressing for CHEMRAWN meetings dealing with Chemistry and Resources of the Oceans, Chemistry and Technology of Water and Waste Water, and a Second World Congress on Future Sources of Organic Raw Materials.

IUPAC is also placing more emphasis on industrial chemistry. The Union seeks greater participation by industrial chemists in its projects, and has formed a Committee on Chemistry and Industry (COCI) to serve as a central communication link between IUPAC and representatives from the chemical industry. Each COCI Committee member is selected from the chemical companies that have joined the IUPAC Company Associate Scheme in one member country.

IUPAC was among the first international Scientific Unions to be formed. Other Scientific Unions were founded at about the same time to encourage international cooperation in astronomy, geophysics and radio science. During the following decades, international unions were also created to deal with pure and applied physics, biological science, geography, crystallography, mechanics, the history and philosophy of science, mathematics, physio-

logical science, biochemistry, geological science, biophysics, nutritional science and pharmacology. The most recent to be formed was the International Union of Immunology, founded in 1976. IUPAC is the largest international Scientific Union.

Like the other international Scientific Unions, IUPAC represents science academies, chemical societies or other appropriate organizations in its member countries; IUPAC now has more than 40 such "National Adhering Organizations". They provide the bulk of IUPAC's operating funds, and have the ultimate say in all policy decisions. Representatives of the National Adhering Organizations form the IUPAC Council, which meets at the conclusion of each IUPAC General Assembly. Major programmes and policies proposed by the IUPAC Officers are subjected to a vote. The Council has the power to accept or reject these proposals, and also to elect new officers from those nominated by its member organizations.

Most IUPAC projects are undertaken by its 35-or-so Commissions and 7 Standing Committees. Commission members are experts in their respective field, and give their time voluntarily for Commission projects. Commissions usually meet every year—once at IUPAC General Assemblies (held every two years), and once during the intervening interval.

The IUPAC General Assembly provides an opportunity for all the constituent bodies (Division Committees, Commissions, Standing Committees and

Subcommittees) to meet, and to hold joint meetings between Commissions whose interests overlap. These are essentially "business meetings", in which each Commission discusses its own procedural matters, nominates new members, organizes Subcommittees or Working Parties, and considers projects to be undertaken in the future. The actual execution of these projects is undertaken later by individual Commission members, who communicate with each other by correspondence.

IUPAC *General Assemblies* are entirely different in character from IUPAC *Congresses*, which are also held every second year. The Congress is an international chemistry conference, in which chemical researchers and leaders from around the world present lectures and poster sessions to discuss recent developments. Each Congress is organized by one of the National Adhering Organizations of IUPAC, and is convened in that host country. The 29th International Congress of Pure & Applied Chemistry is to be held in Cologne, the Federal Republic of Germany on 4 - 12 June 1983, while the 30th IUPAC Congress will be held in the United Kingdom in 1985.

IUPAC conference sponsorship assures free participation and scientific quality

In addition to the IUPAC Congress, IUPAC sponsors 20 - 30 conferences each year. These encompass a wide range of subjects, but all concern chemistry and all must have international participation. As many delegates may be surprised to learn, IUPAC is not directly involved with the organization of most of these conferences. With a few important exceptions, IUPAC does not decide which speakers to invite (although it must approve the conference programme), does not publish brochures, or make arrangements for conference halls, hotels or dormitories. Yet, IUPAC sponsorship has very important implications for those who attend the conference, and those who organize it.

Of foremost importance is the freedom of participation implied by IUPAC sponsorship. Recent upheavals in international relations have exacerbated the restrictions imposed on scientific cooperation and exchange. There have been attempts to bar scientists from Israel, South Africa, USSR and USA (and very likely many other countries) from attending international conferences. Individual scientists are used as a fulcrum for the application of political pressure against governments with opposing political views.

IUPAC sponsorship encourages—even guarantees

—participation by foreign scientists. It enhances attendance by delegates who probably would not otherwise be represented (chemists from Eastern Europe for instance, rarely attend Western conferences except those sponsored by IUPAC) and ensures the widest possible exchange of viewpoints and information.

When conference organizers apply for IUPAC sponsorship, they are asked to seek assurances from their government that all visa applications (submitted sufficiently well in advance) will be processed at least one month before the conference. Usually, communication with government representatives can be undertaken through the National Science Academy, National Committee for Chemistry, or Chemical Society which is the IUPAC member organization in that country. Conference organizers are asked to publish the following notice in all conference brochures:

"IUPAC sponsorship implies that entry visas will be granted to all bona fide chemists, provided application is made not less than 3 months in advance. If a visa is not granted one month before the meeting, the IUPAC Secretariat should be notified without delay by the applicant".

Fortunately, it is rare that intending participants face refusal, although delay in dealing with visa applications is not uncommon. Occasional instances do occur when a chemist wishing to attend an IUPAC-sponsored conference is not granted or promised a visa. If subsequent intervention by IUPAC fails to elicit a visa for a bona fide applicant, IUPAC would withdraw its sponsorship. In accordance with the procedure established by IUPAC (but so far, never invoked), the main invited lecturers would be notified of the reasons for withdrawal of sponsorship, and sponsorship of other meetings in the same country would be suspended until more favourable circumstances prevailed.

Most governments have responded to IUPAC efforts to expedite the granting of visas. Only during one instance in 1976, when a South African applicant was unable to obtain a visa, was it necessary for IUPAC to actually withdraw sponsorship of a conference. Immediately afterward, the host country granted the visa and IUPAC sponsorship was promptly re-instated. In one incident in 1980, visas were promised for two chemists only hours before the deadline for withdrawal of sponsorship.

The procedures developed by IUPAC have proven their effectiveness for attacking barriers to free participation at sponsored conferences. It allows the IUPAC President and Secretariat to respond quickly and decisively when there is need to do so. The procedures were endorsed by the International Council of Scientific Unions (ICSU) at their 15th General Assembly in September 1974. They noted a number of cases in which scientists had been prevented from attending conferences sponsored by the other international Scientific Unions. ICSU urged all scientific unions to adopt the procedures developed by IUPAC and to inform ICSU of any cases in which sponsorship had to be withdrawn.

Other member unions can then take this into account before sponsoring other conferences in the same country.

As well as assuring free participation, IUPAC sponsorship also indicates that the conference will meet high scientific standards. In their application for IUPAC sponsorship, conference organizers are expected to provide a tentative list of invited lecturers. The application is referred to the appropriate IUPAC Division for evaluation. It is recognized, of course, that the organization of each conference must be tailored to suit its subject matter, and that a flexible approach is required in evaluating different types of conferences. Each Division has its own criteria, but several general guidelines are usually considered. It is expected that some lecturers will be recognized leaders in chemical research, but it is also felt that active young researchers should be encouraged to present lectures. Sufficient time (generally, at least 30 minutes) should be devoted to the presentation and discussion of each paper. It is felt that specialized subjects are best discussed in poster sessions, instead of very brief lectures. In order to encourage conference participants to present their findings in the most interesting and informative way, IUPAC makes available to conference organizers its article "Presenting your research results". It provides guidance and advice for participants to prepare their lecture, slides and poster displays. The article has proven extremely popular, and many conference organizers have distributed reprints to their lecturers and poster authors.

Another consideration in the granting of sponsorship is the cost of attending the conference. The expanding role of convention organizing companies and travel agencies in promoting "scientific tourism" is thought largely responsible for the swelling costs of conference registration, social events and

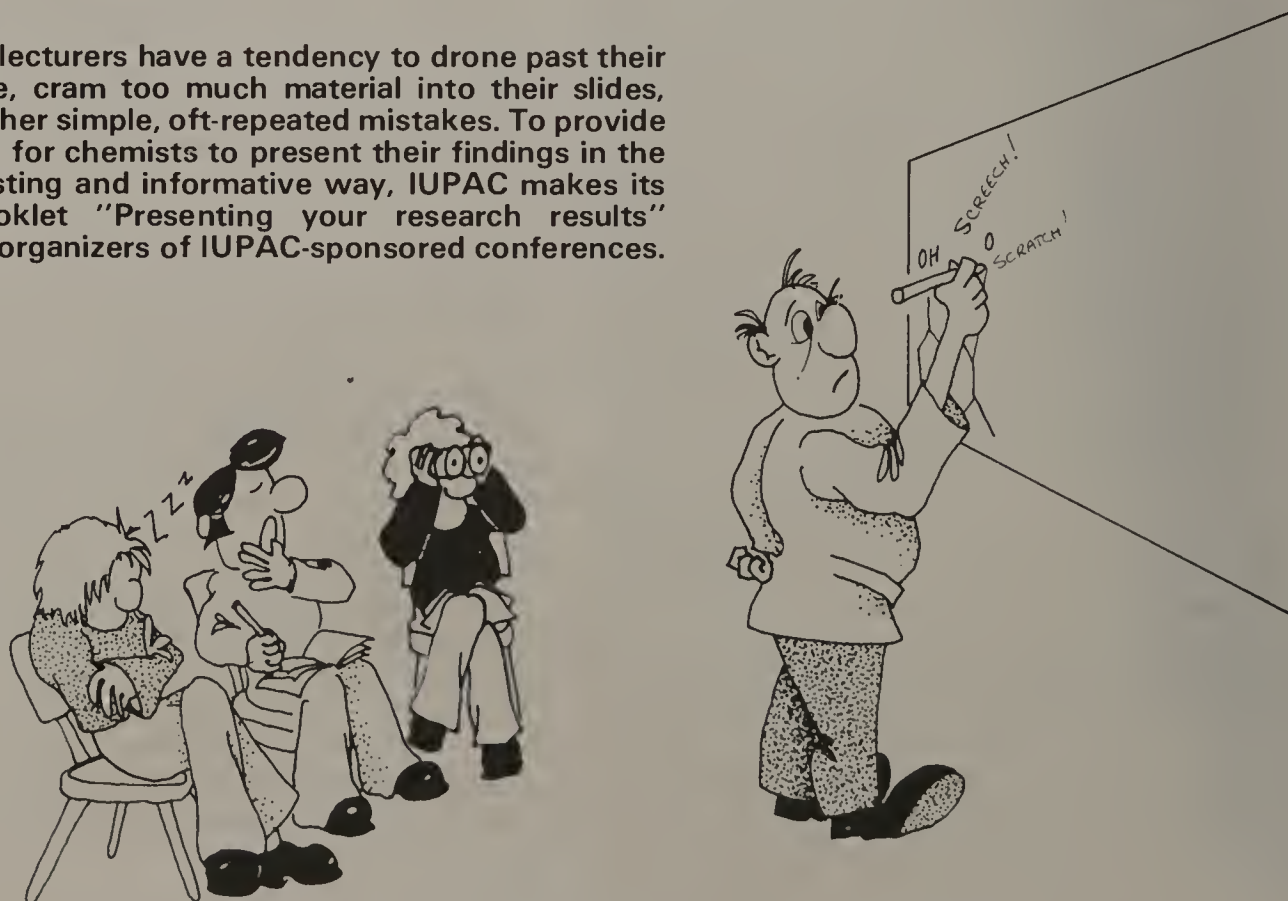
accommodation. To prevent practising chemists being excluded from attending scientific conferences by excessive costs, IUPAC recommends that registration fees be kept to a minimum, and should not be used to subsidize optional social events. Also, efforts to make available low-cost accommodation (usually, in university dormitories) are welcomed.

To be granted IUPAC sponsorship, conferences must have international participation. The lecture programme must not be dominated by scientists from the host country. Plenary lectures should represent the broad spectrum of viewpoints and scientific thought prevailing in different countries. Participation of industrial chemists, as well as chemists from universities, is felt to be highly desirable. To ensure that the conference achieves an international character, it is suggested that the local organizing committee appoint an international advisory committee with expertise in the subject area. For some IUPAC-sponsored conferences, IUPAC Commissions serve as international advisory committees.

IUPAC sponsorship thus indicates to potential applicants that the conference will have both international participation and a high scientific standard. It is a label of quality that is widely recognized in the international chemical community.

Sponsorship by IUPAC also provides a mechanism for publication of main conference lectures. The plenary lectures, those providing a critical survey of the field and giving pointers for the future, are generally published in the official IUPAC journal *Pure & Applied Chemistry*. The content of the journal consists primarily of these lectures (although *Pure & Applied Chemistry* also contains IUPAC Commission reports), and therefore encompasses a wide range of chemical subjects. No other chemistry journal can boast such a broad group of outstanding contributors selected from all countries of the world.

Conference lecturers have a tendency to drone past their allotted time, cram too much material into their slides, and make other simple, oft-repeated mistakes. To provide helpful hints for chemists to present their findings in the most interesting and informative way, IUPAC makes its popular booklet "Presenting your research results" available to organizers of IUPAC-sponsored conferences.



IUPAC chemical nomenclature: a common language for chemists

There is no question that the language and understanding of chemistry have improved enormously since the time of Lavoisier and other chemical pioneers of the eighteenth and nineteenth century. As they discovered new substances, names were assigned in various, sometimes quite arbitrary, ways. Some names were based on the physical or chemical properties of the substance. Those like hydrogen (Greek for "water-producer"), rubidium (Latin for "red"—referring to the colour its salts impart to a flame), and strontium (from the mining town of Strontian in Scotland, where it was first discovered in lead ore) are still very familiar. Others—like muriatic acid, Count Palmer's Powder (magnesium carbonate), Dinglers Green (chromium phosphate) and spirits of hartshorn—can only be regarded as archaic.

By the start of this century, scores of new names were being invented to keep pace with remarkable

those recommended by other IUPAC Commissions and international organizations, IUPAC's Interdivisional Committee on Nomenclature and Symbols consults various bodies before granting its approval for publication.

New nomenclature recommendations are published in the IUPAC journal *Pure & Applied Chemistry*. For the convenience of nomenclature users, much of this nomenclature has been compiled into a few main guidebooks, which are revised and updated periodically. These include *Nomenclature of Inorganic Chemistry* (with its companion guide "How to name an Inorganic Substance") and *Nomenclature of Organic Chemistry* (available in hardcover and softcover editions). Nomenclature approved by the Joint Commission on Biochemical Nomenclature has been compiled by the International Union of Biochemistry into a softcover manual *Biochemical Nomenclature and Related Documents*.

Of course, chemical nomenclature includes not only the names of chemical compounds, but also terminology, symbols and units. Terminology for a range of analytical procedures (from gravimetric analysis to ion-selective electrodes) have been recom-

"Every branch of physical science must consist of three things; the series of facts which are the objects of science, the ideas which represent these facts, and the words by which these ideas are expressed ... As ideas are preserved and communicated by means of words, it necessarily follows that we cannot improve the language of any science without at the same time improving the science itself; neither can we, on the other hand, improve a science without improving the language or nomenclature which belongs to it."

A. L. Lavoisier, 1780

advances in organic chemistry. No attempt was initially made to systematize or categorize the thousands of new compounds being prepared. As a consequence, organic chemistry might soon have degenerated into a structureless assembly of new reactions and compounds, a situation similar to that which prevailed in inorganic chemistry before the advent of the periodic table. However, chemists soon realized that they could not simply generate new names as the number of new compounds continued to swell. They foresaw a growing likelihood of conflict, confusion and—ultimately—chaos. Accordingly, they began the first attempts to devise *systematic* names according to the chemical structure of each compound. In this way, a virtually unlimited number of compounds could be named by combining a relatively few word stems, according to a few unambiguous rules. The task of devising a complete system of chemical nomenclature was undertaken by IUPAC. Its nomenclature Commissions continue to revise, update and extend their rules as new families of chemical compounds are discovered or synthesized (more than 5.6 million compounds have now been described in the chemical literature).

Three IUPAC Commissions deal respectively with nomenclature of inorganic, organic and macromolecular compounds, and a joint IUPAC - IUB Commission is concerned with nomenclature of biochemical compounds. To ensure that new nomenclature recommendations are consistent with

mended by several IUPAC Commissions in the Analytical Chemistry Division, and have been compiled into a hardcover guidebook *Compendium of Analytical Chemistry*. In addition, recommendations for terminology and guidelines for presenting spectra have been published for all main spectroscopic techniques.

Various Commissions have recognized a need for standardized nomenclature in their respective area of expertise, and have responded by publishing nomenclature recommendations covering their field of specialization. Among the nomenclature documents of this type that have been published are an extensive *Glossary of terms used in physical organic chemistry*, a report on *Symbolism and terminology in chemical kinetics*, and a listing of *Quantities and units in clinical chemistry*.

An important project being undertaken by the Commission on Physical Organic Chemistry is the development of systematic methods for naming chemical transformations and mechanisms. Presently, most reactions are described by the names of their discoverers (Diels-Alder and Wurtz reactions, for example), inconsistent descriptive terms, or sometimes only as an equation. The proposed system for naming chemical transformations is intended to satisfy the need for short, pronounceable and distinctive terms for use in speech and writing.

Many IUPAC nomenclature reports describe not only the terminology, symbols and units that authors

should use when publishing their experimental results, but also provide guidance about *how* experimental results should be reported. It is essential, of course, that authors provide sufficient information about experimental procedures and conditions so that other investigators can repeat their experiments. Some experimental techniques are so commonly used, and procedures are so standardized, that there is no point describing them, while other experimental details are of crucial importance. The IUPAC recommendations provide guidance for authors so that their published work can have the greatest possible value. One example is provided by calorimetric measurements of cell metabolism, for which many workers still report heat evolution in arbitrary terms like "mm recorder deflection". Published results would have a more general and lasting value if calorimeters were calibrated, the Interunion Commission on Biothermodynamics stressed in a recent report. This Commission, whose members represent the three international scientific unions dealing with chemistry, biochemistry and biophysics, notes that calibration of a calorimeter is now a relatively simple procedure and urges all biothermodynamicists to report their results in terms of real heat units.

Standard test methods: common ground for chemical research

As more and more cooperative research programs are undertaken by laboratories in different countries, it is becoming increasingly important to establish uniform methods of chemical analysis, capable of providing consistent results when performed by different individuals in different countries.

When trace concentrations of substances are measured, it is often difficult to ensure that any laboratory result is a reliable absolute value. Very different results can be obtained by various laboratories, each using their own test procedures. The failure to recognize the importance of standardized test methods had been a common cause of incorrect interpretation of results, wrong conclusions, and even serious disputes between buyers and sellers of chemical commodities.

IUPAC Commissions have been very active in developing standard test methods, and in coordinating collaborative testing to ensure that different laboratories throughout the world achieve consistent test results. For example, IUPAC groups have recently published reports which recommend or discuss standard methods for measuring concentrations of mercury, copper and mycotoxins in foodstuffs; residues of pyrethrin insecticides; nutritional value and impurities in Single Cell Protein; trace metals in lead alloys; and determination of steroids, aldehydes and ketones.

Publication of uniform testing procedures is the main function of the IUPAC Commission on Oils, Fats & Derivatives. The group, which has published a hardcover reference source *Standard Methods for the Analysis of Oils, Fats & Derivatives*, periodically replaces outdated tests and recommends new test

procedures as their need becomes apparent. Since their main reference book on standard test methods was published, the Commission has issued a number of new and revised test methods. These include the determination of oil content by low-resolution NMR, analysis of tocopherol (vitamin E) and measurement of organochlorine pesticides in vegetable oils, margarine and other food products.

Before a test method can be universally accepted as a standard reference method, collaborative studies must establish that accurate and reliable results can be obtained by participating laboratories in several countries. To compare results of nickel analysis obtained by various clinical laboratories, for example, the IUPAC Subcommittee on Environmental and Occupational Toxicology of Nickel conducted two collaborative surveys. They submitted identical urine specimens to laboratories in seven countries, and compared the results of their nickel analysis. Wide discrepancies in nickel concentrations were initially reported by the participating laboratories. Although all laboratories had utilized atomic absorption spectrometry to determine nickel concentrations in the samples, the analyses differed in sensitivity, precision and nickel recovery, depending upon the preliminary pretreatment of the sample. Troublesome contamination problems were encountered during the initial oxidation and preconcentration of urine samples (which typically might contain only a few parts-per-billion of nickel). Samples were sometimes contaminated by the nickel content of sweat on the hands of the analyst, by leaching of nickel from micropipet tips, and by traces of nickel present in evacuated tubes used to collect the samples.

There has hitherto been no critical review of analysis methods for measuring nickel concentrations in biological materials. The Subcommittee prepared a report discussing the *Analytical biochemistry of nickel*, and proposed a standard reference method for the analysis of nickel in blood serum and urine.

Results of a subsequent collaborative trial were presented at an International Conference on Nickel Toxicology. Members of the Subcommittee concluded that the latter test results demonstrated substantial progress towards harmonization of nickel analysis in body fluids. The IUPAC Commission on Toxicology, meeting in conjunction with the conference, was able to settle remaining technical details about the Reference Method (regarding preparation of reagents, washing of plasticware and conditions of acid digestion) and approve its publication as a tested procedure for analysis of nickel in serum and urine.

The Subcommittee on Environmental and Occupational Toxicology of Nickel is now embarking on a project to extend the Reference Method to the analysis of nickel in whole blood and in tissue samples. The parent Commission has also created additional subcommittees to establish standard reference methods for analysis of cadmium and aluminum in biological samples.

Although each element or analyte presents specific problems for the analyst, some *general* considerations apply to all trace analytical methods. These general aspects are discussed in a series of reports being prepared by the Commission on Microchemical

Techniques and Trace Analysis. They consider contamination in trace analysis, standard reference materials for trace analysis, comparison of trace analytical methods for determining concentrations of elements, stability of synthetic standard solutions, applications of pressurized sample dissolution for trace analysis of biological materials, and practical limits of determination with trace analytical methods.

Analysis of pesticide residues in soil and food at the part-per-million level of concentration normally requires sophisticated methods and expensive instrumentation. These methods are generally not suitable for use in developing countries. There, the equipment would likely be prohibitively expensive, or (with poor service facilities) unworkable.

To illustrate the value of *simple* analytical methods that are suitable for pesticide analysis, the IUPAC Commission on Pesticide Chemistry undertook a project to examine the literature of pesticide residue analysis. The Commission sought analytical methods that were simple, selective in their response to particular types of pesticides, and which approach the accuracy and precision of existing methods based on gas-chromatography and high-pressure liquid chromatography. Only those methods not requiring expensive equipment, large volumes of solvents, or materials of higher purity than are commonly available were considered. The results of the project are contained in their report *Development and Evaluation of Simplified Approaches to Residue Analysis*.

The report identifies Thin Layer Chromatography (TLC) as a simple but effective technique that can be applied to a wide range of insecticides, herbicides and fungicides. The four Commission members who carried out the study found that "TLC is simple, fast, sensitive and can be specific. It equals or even surpasses other techniques used in residue analysis with regard to speed and cost. It appears to be ideally suited to the needs of developing countries". They also reported that semi-quantitative results can be obtained simply by looking at a developed TLC plate and estimating the relative size and intensity of spots. To improve accuracy, TLC plates can be examined with a double-beam densitometer. The development of such equipment during the last decade has so improved the accuracy that can be attained with TLC, that it now often compares favourably with more sophisticated techniques.

The IUPAC Commission on Pesticide Chemistry is also preparing a manual for conducting pesticide residue trials. It discusses sampling of food and feed, good analytical practice, and interpretation of

analytical data in relation to proposed maximum residue limits established by WHO/FAO. This project is a response to the urgent need for international harmonization of procedures for producing and evaluating pesticide residue data. The manual will be an important reference source for developing countries initiating pesticide control programmes, and should be of value to all scientists and administrators engaged in pesticide residue analysis.

Data compilation: 100 years of chemistry at your fingertips

Nestled within millions of pages of experimental results reported in the chemical literature is an extraordinary wealth of chemical information. The problem is to make this information readily available to the individuals who need it. That is no simple task, since measurements on acid - base dissociation constants, stability constants of complexes, thermodynamics data, oxidation - reduction potentials, reaction rate constants and solubility data are scattered throughout the chemical literature. Measurements have often been made by several different groups, each using their own experimental procedures. In some cases, the reported experimental values may differ considerably or be entirely inconsistent (reported melting points of CaO, for example, differ by as much as 300°C). The non-expert would be ill-prepared to compare these different values, and assess which are likely to be most reliable and accurate.

IUPAC plays an important role in compiling and evaluating chemical data. About 30 books have now been published in IUPAC's *Chemical Data Series*, and within the last few years, IUPAC has launched its *Solubility Data Series*. This has already become the most comprehensive collection and evaluation of solubility measurements ever undertaken. When complete, the *Solubility Data Series* will contain about 100 volumes and include data on virtually every solid, liquid and gaseous compound that dissolves in some solvent. This massive project is based on a conceptually new approach in treating scientific numerical data. Each solute - solvent system is described in two parts. Firstly, data sheets present all reliable experimental values, as they appear in the primary information source. Secondly, an expert for that system discusses and evaluates the quality of the available data, limitations of the

"Data evaluation and compilation is considered routine and not at the frontiers of science. However, the lack of compiled data is a tremendous handicap to the development of the frontiers."

Lack of support for critical compilation of data "is a 'tragedy of the commons' in which action of value to the general (chemical) community cannot compete with activities of special interest to individual scientists."

US National Research Council report, 1980

experimental methods, and reproducibility of measured values. Those results thought to represent the best available data are presented, and graphical plots are provided where appropriate.

Besides the Commissions on Equilibrium Data and Solubility Data, which coordinate the compiling, editing and evaluation of data for the *Chemical Data Series* and *Solubility Data Series*, other IUPAC Commissions undertake specialized data compilations on a smaller scale. For example, the Commission on High Temperature and Solid State Chemistry surveys the literature and publishes a comprehensive *Bibliography on the High Temperature Chemistry and Physics of Materials*. Each issue of the bibliography typically contains several hundred literature references dealing with devices for achieving, measuring and controlling high temperatures; and with thermodynamic properties and reactions at temperatures above 700°C. The Commission is also preparing a series of reports in which they compile and evaluate melting temperatures of refractory oxides, and recommend preferred values.

The organization of IUPAC

IUPAC is a diffuse organization. More than 1000 individuals from academic, industrial and government laboratories throughout the world serve as members of its Divisions, Commissions and Working Parties. IUPAC also interacts with its 44 member science academies and chemical societies (its "National Adhering Organizations"), nearly 200 chemical companies which participate in the Company Associate Scheme, and some 25 Associated Organizations (dealing with a wide range of chemical subjects, from cereal chemistry to water pollution research). Not only are these individuals and organizations located around the world, but their interests and expertise span the entire spectrum of chemistry. Only once every two years, at the IUPAC General Assembly, do they actually come together and meet each other personally.

Coordinating the hundreds of projects being undertaken at any one time is a complex task. Procedures have been developed so that each group informs other bodies of its progress and future plans, and obtains approval when required. Much of the correspondence is channelled through the IUPAC Secretariat in Oxford, England. The small group of employees on the Secretariat staff help organize each General Assembly meeting, oversee the production of IUPAC publications, direct information to relevant organizations and individuals, and respond to enquiries.

Responsibility for day-to-day policy decisions lies with the President and other IUPAC officers, the Treasurer, Secretary-General and Vice-President (who will become President for the following two-year term). Only the President, or his designated representative, has the authority to grant IUPAC sponsorship to a conference, to appoint members of

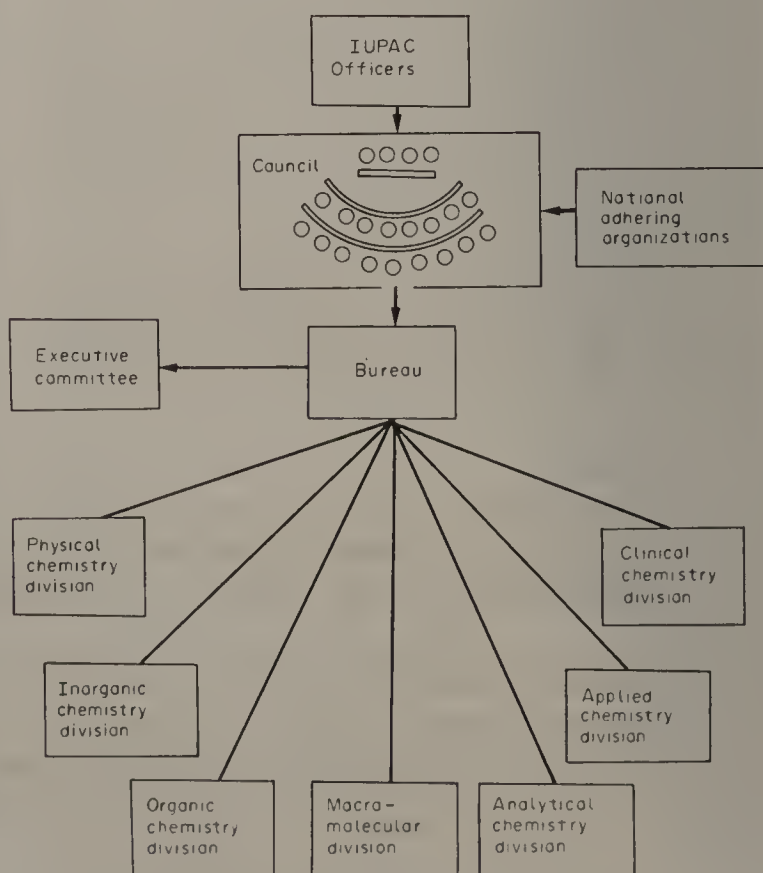
Standing Committees, and sign official correspondence. The President chairs the Council meeting held at the conclusion of each General Assembly. IUPAC officers are elected by the Council, and are ultimately responsible to this body. Major policy decisions (for example, the creation of a new Commission, or change of function of an existing Commission) must be approved by a vote of the Council.

Delegates to the Council are selected by the 44 national member organizations. Each "National Adhering Organization" can send between one and six delegates, depending upon the category of that country (determined by the size of its chemical industry). Developing countries may also be represented by a non-voting observer.

Because the Council is such a large body (with as many as 170 delegates in attendance) and meets just once every two years, it can only deal with major policy decisions of long-term significance. A smaller body, the Bureau, acts on the Council's behalf during the two-year interval between General Assemblies. The Bureau consists of the IUPAC officers (including the immediate Past-President), Presidents of each of IUPAC's seven Divisions, and ten (or more) members elected by the Council. The Division presidents act as a link with their constituent Commissions, which form the scientific base of IUPAC. They may recommend to the Bureau areas for collaborative work involving two or more Divisions. The Bureau generally meets once each year.

The IUPAC officers and a few of the Elected Bureau Members form the Executive Committee. This small body (containing a maximum of eight members) can meet on relatively short notice, when important matters arise suddenly which require a prompt policy decision.

The Executive Committee may establish Standing



Committees which, among their other functions, advise the President and Executive Committee. The Finance and Publications Committees, for example, provide information and guidance about financial matters and publications policy. The Committee on Teaching of Chemistry advise the President and Executive Committee about educational matters, as well as acting as a coordinating body for chemical education activities throughout the world. The Committee on Chemistry and Industry, which represents the IUPAC Company Associates, may point out ongoing needs of the chemical industry which could be met by IUPAC. An important coordinating role is played by the Interdivisional Committee on Nomenclature and Symbols (IDCNS). As well as advising the Executive Committee of appropriate experts that might be appointed to fill vacancies arising

in those Commissions concerned with nomenclature, IDCNS plays a crucial role in ensuring that all new IUPAC nomenclature recommendations are consistent with those that have been recommended by other IUPAC nomenclature Commissions. Before any nomenclature recommendations are published as a IUPAC document, IDCNS ensures that consultations have taken place among all IUPAC Divisions, other Scientific Unions and international organizations involved with standardization of nomenclature and symbols. One multi-disciplinary subject in particular, biothermodynamics, encompasses nomenclature from biochemistry, biophysics and chemistry. A special joint Commission on Biothermodynamics has been formed, with members drawn from IUPAC and the two other Scientific Unions concerned with this subject.

RECENT REPORTS

Separation & Preconcentration of Trace Substances Part III. Flotation as a Preconcentration Technique

Flotation is one of the most recently introduced separation techniques used in trace analysis. Precipitates or soluble species in aqueous media can be selectively floated to the solution surface and thereby concentrated by a rising stream of gas bubbles with (or sometimes without) the aid of surfactants. This report reviews the applications of the variants of this technique in trace analysis, with many detailed examples included, such as the preconcentration of molybdenum (VI) at the $\mu\text{g l}^{-1}$ level in seawater and of copper and silver in high-purity lead and zinc metals. Numerous other procedures are tabulated. The effectiveness of the technique is evaluated critically, and means of achieving conditions for optimal separation are reported.

This technical report, prepared by the Commission on Microchemical Techniques and Trace Analysis, will be published in the July or August issue of *Pure & Applied Chemistry*.

Constitutive equations from Gaussian molecular network theories in polymer rheology

Molecular theories are widely used to predict flow behaviour of polymer liquids and compare these with experimental data. We believe that the value of such

theories rests not only on the extent of agreement found in such comparisons, but also on the logical foundations of the theory. In some cases, it seems that progress in comparing predictions with data has outstripped progress in understanding both the logical foundations and the steps taken to derive useful equations from the molecular model used. The aim of the present paper is to take a modest step towards restoring the balance: we have selected a few related theories and have simply listed what we believe to be a complete set of underlying assumptions made in each case. We hope that this will serve as a helpful starting point for future critical assessment of the value of these theories. We do not give derivations of final equations, since these are available in the original papers, nor do we give comprehensive comparisons with experimental data. We recognize that a thorough assessment of any one molecular theory should make use of all available structural information obtainable from "non-rheological" techniques of characterization.

This technical report is scheduled for publication in the July 1982 issue of *Pure & Applied Chemistry*.

Physico-Chemical Data for some selected Mycotoxins

Physico-chemical data (i.e. melting point, specific rotation, circular dichroism, ultra-violet absorption spectrum, infrared absorption spectrum, electron impact mass spectrum and the nuclear magnetic resonance spectrum) have been determined of the following 15 mycotoxins: aflatoxin B₁, austdiol, citrinin, cytochalasin B, α -cyclopiazonic acid, diacetoxyscirpenol, fumitremorgen B, ochratoxin A, patulin, penicillic acid, roridin A, secalonic acid D, sterigmatocystin, T-2 toxin and zearalenone. This report presents physicochemical data for these mycotoxins, and discusses the techniques and equipment used to characterize mycotoxins.

Publication of this technical report is scheduled for the July or August issue of *Pure & Applied Chemistry*.

Recommendation on reporting electrode potentials in non-aqueous solvents

Comparison and compilation of definite and reliable electrode potentials in non-aqueous solvents have been severely hindered, since insufficient attention has been paid to reference electrodes employed in measuring such data. Measurements made versus aqueous reference electrodes include liquid junction potentials that may neither be reproducible nor stable. Reliable reference electrodes in non-aqueous solvents are generally limited to one or a few solvents only and their potentials depend on the nature of the solvent.

It is therefore recommended that the redox couples ferrocene/ferrocenium ion (ferrocene: bis(η -cyclopentadienyl)iron(II) and bis(biphenyl)chromium(I)/bis(biphenyl)chromium(O) be employed as reference redox systems.

Procedures for measuring and reporting electrode potentials in non-aqueous solvents versus these reference redox systems are given in this recommendation. The difference in electrode potentials obtained for ferrocene/ferrocenium ion and bisbiphenyl-chromium(O)/bisbiphenylchromium(I) ion for twenty two solvents obtained by polarography and cyclic voltammetry are listed. Both of the recommended reference redox systems approach a solvent independent redox system as closely as presently known. Electrode potential data reported versus these systems permit the comparison of electrode potentials for a given system in different non-aqueous solvents and thus allow studies on the solvent effects on electrode potentials in non-aqueous systems in compiling and comparing data obtained in different solvents.

This provisional nomenclature report will be published in *Pure & Applied Chemistry* during the latter half of 1982.

Manual of symbols & terminology for physicochemical quantities and units Appendix IV: Notation for states & processes, significance of the word 'standard' in chemical thermodynamics and remarks on commonly tabulated forms of thermodynamic functions

The long established IUPAC Manual of symbols and terminology proffers the basic symbolism needed in chemical thermodynamics, Appendix I to the Manual contains a more detailed treatment of one aspect of the subject, that dealing with the activities of substances, pure or mixed. Now for the further guidance of physical chemists, Appendix IV to the

Manual has been prepared by the IUPAC Commission on Thermodynamics. It advises on suitable symbols and formats for describing thermodynamic processes and states of aggregation of substances, and for tabulating certain thermodynamic functions, needed for calculations. Also treated in more detail than in the Manual itself is the proper usage of the word 'standard' in the context of thermodynamics. The important proposal is made that the standard-state pressure should henceforth be taken as 10^5 Pa, in preference to the previous value of 1 standard atmosphere (101 325 Pa), and the effect of this change on current tabulations is outlined.

Appendix IV of the Manual is to be published in *Pure & Applied Chemistry*, Vol. 54, No. 6 (June 1982), pp. 1239 - 1250.

Thermodynamic and transport properties of pure and mixed thermal plasmas at local thermodynamic equilibrium (LTE)

This report was prepared by a task group on transport phenomena in thermal plasmas at the request of the IUPAC sub-committee on plasma chemistry under the chairmanship of Dr. Claude Bonet who was at that time at the CNRS-Laboratoire des ultra-réfractaires, Odeillo, Font-Romen, France. The mandat of the group was to conduct a review of the available scientific literature published over the period from 1950 to 1978 on the thermodynamic and transport properties of pure and mixed gases at atmospheric pressure under plasma conditions. Specifically, the following properties were examined.

Thermodynamic properties: Heat capacity at constant pressure (C_p) and constant volume (C_v) and the specific enthalpy (h).

Physical properties: Density (ρ)

Transport properties: Thermal conductivity (k), dynamic viscosity (η), electrical conductivity (σ) and the diffusion coefficient (D_{AB}).

Radiative properties: Spectral and total emission coefficient (ϵ_v , ϵ), spectral and total absorption factors (α_v , α) and the radiation power per unit volume (U).

The review was limited to the thermal plasmas of the following pure gases or their mixtures at local thermodynamic equilibrium (LTE). Ar, He, H₂, N₂, O₂, CO₂, Air, Xe and Kr.

A total of 173 references were collected and compiled in a standard format for quick reference identifying the properties studied by each worker, the gases, the temperature and pressure ranges covered. Whenever possible, distinction was also made between experimental and theoretical investigations.

This technical report will appear in *Pure & Applied Chemistry*, Vol. 54, No. 6 (June 1982), pp. 1221 -1238.

COURSES

Organic Chemistry for Industrial Research Chemists

17 October - 3 December, 1982
University of East Anglia, Norwich, UK

This is a major refresher course in modern organic chemistry intended for senior chemists in industry who have completed their university training in chemistry at least eight years previously. The course emphasizes advances in theory and practice that have taken place in the last ten years. Chemists wishing to take the course need not necessarily possess a PhD or similar formal qualification, but should hold a position of responsibility comparable with those held by PhD chemists.

The course is held during a seven-week period, commencing in mid-October. In addition to morning lectures, the student will attend seminars, talks by visiting speakers from industry, and literature sessions. Active participation by students is encouraged. A permanent faculty member at the university will be assigned as the student's Advisor, and will meet with the student at least once a week. Organized social events will be held so that students can meet permanent chemistry faculty, post-doctoral and graduate students, as well as chemists visiting the university through various foreign exchange schemes.

The combined University and School fee for the course is £1000. The student is also expected to pay travel and subsistence expenses. Enquiries regarding this course should be made to Professor A. McKillop, School of Chemical Sciences, University of East Anglia, Norwich NR4 7TJ, England.

Organic Chemistry teaching & research for teaching staff in universities

7 October - 3 December, 1982
University of East Anglia, Norwich, UK

This course is a major refresher course in modern organic chemistry and chemical education for university-level teaching staff, especially those overseas. The course emphasizes advances in theory and practice that have taken place during the last ten years. It is particularly suitable for those who, as a result of increasing administrative responsibilities, isolation or specialization, have found it difficult to maintain as close contact as they would wish with recent major advances in organic chemistry and teaching methods. Possession of a PhD is not required, but those accepted for the course must hold positions of responsibility that would normally require a PhD in chemistry.

During the seven-week course, the student will attend morning lectures, seminars, research talks by visiting speakers, and colloquia. A permanent faculty member will be assigned as an Advisor and meet with the student at least once a week. Organized social events will enable the student to meet permanent faculty members, post-doctoral and graduate students. Although the course does not involve practical laboratory work, students are encouraged to take an interest in research carried out in the School of Chemical Sciences. It is hoped that some participants will stay on at the University of East Anglia after completion of the course, and become involved in some cooperative research project.

The combined University and School fee for the course is £1000. Students must also be prepared to pay travel and subsistence costs. Further information about the course can be obtained from Prof. A. McKillop, School of Chemical Sciences, University of East Anglia, Norwich NR4 7TJ, England.

Biochemical Separation Methods

22 March - 7 June, 1983
University of Uppsala, Sweden

This ten-week course is centered around modern analytical and preparative methods for the separation of cells, viruses, proteins and nucleic acids, and their characterization. It consists of lectures and laboratory work dealing with moving boundary electrophoresis, free zone electrophoresis, zone electrophoresis in both sieving and non-sieving media, isoelectric focusing, displacement electrophoresis, molecular sieve chromatography, hydroxyapatite chromatography, hydrophobic interaction chromatography, covalent chromatography, bioaffinity chromatography, gas chromatography, HPLC, counter-current distribution (liquid phase partition), analytical and preparative centrifugation methods (centrifugation in different kinds of density gradients, determination of sedimentation coefficients and of molecular weights), immunodiffusion, immunoelectrophoresis, determination of diffusion coefficients, light scattering, spectrofluorometry, bioluminescence and radioimmunoassay. The course has been organized by Professors Stellan Hjerten and Paul Roos at the University of Uppsala's Institute of Biochemistry.

Knowledge of biochemistry and mathematics corresponding to a basic university degree is required. Good knowledge of English is necessary. The number of participants is limited to 12, 6 from Sweden and 6 from abroad. The course fee is US\$450, but students are also expected to pay living expenses. The cost of food and accommodation in student rooms will be a minimum of US\$1600. The closing date for applications is 15 January, 1983. Application forms can be obtained from the Secretary Eva Linder at the Institute of Biochemistry, University of Uppsala, Box 576, S-751 23 Uppsala, Sweden.

CHEMRAWN II

International Conference on Chemistry & World Food Supplies: The New Frontiers

6 - 10 December, 1982
Manila, The Philippines

CHEMRAWN II is among the first major international conferences to involve world leaders from government, industry and academia for the purpose of probing the priorities and future research directions which could best meet mounting food problems. CHEMRAWN II will provide an independent, nonpolitical central forum for the discussion of critical needs and solutions relating to chemistry, agriculture and world food supplies. It will be an interdisciplinary meeting bringing together the most modern aspects of chemistry, biochemistry and microbiology relating to agricultural production and food processing. However, CHEMRAWN II is more than a scientific conference: it will treat agriculture and food production as a system, taking into account social, economic and environmental factors—as well as the technical components involved. Special attention will be given to strengthening the indigenous food-producing capacity of developing nations. Scientists and government leaders from developing countries will be involved in all phases of the conference.

The first day of the conference will feature keynote addresses by major world leaders, who will examine economic, social and political factors, and the potential for new chemical and agricultural developments to meet the world's growing food needs. Among those speaking will be Dr. M. S. Swaminathan, Director-General of the International Rice Research Institute; Dr. W. David Hopper, South Asia Regional Vice-President of the World Bank; Dr. Louis Von Planta, Chairman of Ciba-Geigy Corporation; Dr. Thomas Odhiambo, Director of the International Centre of Insect Physiology and Ecology; and Nobel Laureate Melvin Calvin, Professor at the University of California. Introductory addresses will also be made by IUPAC President Nagakura; Ferdinand E. Marcos, President of the Republic of the Philippines; and the Philippine Minister of Agriculture, Mr. Arturo Tanco, Jr.

During the second day, concurrent sessions of invited technical papers will be held. These will be presented by scientific and technological leaders at the forefront of their fields. They will consider the present status of science and technology relating to

food production, and the role of chemistry in raising agricultural productivity.

A technical session dealing with new frontiers in food production and processing will be held during the third and fourth days of the conference. In addition, an afternoon field trip will include a visit to the International Rice Research Institute and the University of the Philippines.

The following papers will be presented during the technical sessions on the second, third and fourth days of the conference:

Soil and Crop Management for Efficient Use of Water & Nutrients

The Role of Chemistry in Removing Soil Constraints to Crop Production

Improving the Efficiency of Nitrogen Fixation (Chemical and Biological)

Developing More Efficient Fertilizer, Raw Materials, Manufacturing, Formulation, Storage

Modifying Crop Performance With Chemicals: Growth Control, Fruit-Set, Ripening, Harvesting, Storage

Improving Saline, Alkaline, Acid, and Toxic Soils and Low-Quality Soils and Waters

Chemical Approaches to Increasing Water Availability to Crops, Including minimum Tillage Systems

New Developments in Chemical Control of Weeds

Chemical Techniques for Improving Survey Monitoring and Analysis, and Avoiding Pollution of Soil and Water Resources

Integrated Approaches to Pest Management

Principal Pests of Food Crops

Principal Diseases of Food Crops

Interactions Among Pests, Diseases, and Weeds in Farming Systems

The Biochemical Basis of Host Resistance

Naturally Occurring Pesticides and Their Potential

Pheromones and Other Recent Developments in Biochemical Pest Management

The Potential for the Integration of Biological, Chemical, Mechanical, and Agronomic Techniques of Pest Control in Farming Systems

Environmental Aspects of Pest Management

The Role of Chemistry & Biochemistry in Improving Animal Production

Nitrogen Sources and Roughage in Ruminant Nutrition

The Use of Sugarcane and By-Products for Livestock

Advances in Fodder Conservation Techniques

Recent Developments in Feed Additives

Biochemical and Chemical Contributions to Efficient Small-Scale Pig and Poultry Systems

Aquaculture Systems: Problems in Breeding, Feeding, Pesticides, and Water Purity

Chemistry in the Control of Ruminant Animal Diseases and Reduction of Physical and Biological Stress

Chemistry in the Control of Onchocerciasis and Human and Animal Trypanosomiasis

Contributions of Chemistry & Biochemistry to Developing New & Improved Food Sources

Synthetic Foods: Technical, Economic, Esthetic, and Cultural Issues

New Sources of Food and Feed

Conversion of Plant and Animal Waste to Food

Improving the Supply, Quality, and Utility of Carbohydrates

Improving the Supply, Quality, and Utility of Fats

Improving the Supply, Quality, and Utility of Proteins

Expanding and Improving the Food Supply With Enzymes

Learning from Successes and Disasters in Fortifying Food

Chemistry and Biochemistry in Food Processing & Storage

Overview of Storage and Processing

Fish Processing

Progress in Preservation by Fermentation

Chemical and Biological Pretreatment of Food for Drying

Prestorage Processes for Wheat

Occurring Toxicants and Antinutrients, Including Mycotoxins

Effects on Nutritional Quality of Chemical Changes in Processing and Storage

Water Activity and Intermediate Moisture Foods

Chemistry in the Assessment and Control of the Food Supply

Overview of Assessment and Control

Food Composition Tables: Are they Useful and Necessary?

Rapid, Simple Testing For Contaminants and Toxicants

Rapid, Simple Testing for Nutrients as an Aid to Selective Breeding

Multivariate, Non-Destructive Analysis of Raw Materials

The Important Difference Between Chemical Analysis and Biological Availability

Problems of Correlation and Definition in Analytical Techniques

Water Treatment for Use in Food Processing

The Forward Edge

Overview of the Potentials and Prospects in Genetic Engineering

Applications of Genetic Engineering to Plant and Animal Production

The Application of Wide Crosses to Plants

Improved Conventional Strategies and Methods for Selection and Utilization of Germ Plasm

Biochemical and Genetic Approaches to Increased Nitrogen Fixation

The Role of Growth Regulators and Hormones in Enhancing Food Production

The Potential Contribution of Cell and Tissue Culture to Crop Improvement

Photosynthetic Activity and Partitioning

New Approaches to Increased Meat Production

Biorational Design of Chemicals

Special Plenary Lecture

Food and Energy: Interdependent World Needs by Nobel Laureate Sir George Porter

Technical papers will also be presented during the conference in poster sessions.

The final day of the conference will include presentations by Nobel Laureates Abdus Salam (of the International Centre for Theoretical Physics) and Norman Borlaug (of the International Maize and Wheat Improvement Center). Lecture session Chairmen will present their analysis of the major developments discussed at the conference.

About 3 months after the conference, each participant will be sent a copy of the book containing plenary lectures (presented on the first and fifth days of the conference) and the conference Summary and Recommendations for follow-up action. This publication will be made available to policymakers in government agencies, industrial organizations, and educational and research institutes worldwide.

Scientific papers presented in the technical sessions of the conference will be published separately as the "Conference Scientific Papers".

CONFERENCES

IUPAC meetings are indicated in bold type
Additional information from address in parentheses

1982

CENTRALIZED WASTE DISPOSAL

September 20 - 23. 1st International Symposium on Centralized Chemical Waste Management. Odense, Denmark.

(Denise Cooley, Battelle's Columbus Division, 505 King Avenue, Columbus, OH 43201, USA.)

FOOD RESEARCH

September 20 - 23. IUFOST Symposium on Food Research and Data Analysis. Oslo, Norway.

(Dr. H. Martens, Norwegian Food Research Institute, P.O. Box 50, N. 1432, As-NLH, Norway.)

CARBON & GRAPHITE

September 20 - 24. 6th International Carbon and Graphite Conference. Imperial College, London, UK.

(The Conference Secretary, CARBON'82 (Sixth London International Carbon & Graphite Conference) Society of Chemical Industry, 14/15 Belgrave Square, London SW1X 8PS, UK.)

MOLECULAR CRYSTALS

September 20 - 24. 10th Molecular Crystal Symposium. Canada.

(Daniel Chartrand, Executive Secretary, 10th Molecular Crystal Symposium, National Research Council of Canada, Ottawa, Ontario, Canada K1A 0R6.)

BIOMASS UTILIZATION

September 20 - 30. NATO Advanced Study Institute Course on Biomass Utilization (S.81/23). W. Virginia, USA.

(Dr. H. Sobel, Biosources Digest, P.O. Box 1979, Santa Monica, CA 90406, USA.)

SURFACE SPECTROSCOPY TECHNIQUES

September 20 - 24. Course on Modern Surface Spectroscopy Techniques. TX, USA.

(Howard Hendrickson, University of Texas, Cockrell Hall 2, 102, Austin, TX 78712, USA.)

CHEMISTRY/UK

September 21 - 23. The Royal Society of Chemistry Autumn Meeting '82. Heriot-Watt University, Edinburgh, Scotland.

(Dr. John F. Gibson, The Royal Society of Chemistry, Burlington House, London W1V 0BN, UK.)

RADIATION CURING

September 21 - 23. 6th International Radiation Curing Conference. Chicago, USA.

(Susan E. Buhr, Association for Finishing Processes of SME, 1 SME Dr., POB 930, Dearborn, MI 48128, USA.)

FOLIC ACID DERIVATIVES

September 21 - 24. 7th International Symposium on Pteridines and Folic Acid Derivatives. St. Andrews University, Scotland.

(Prof. H. C. S. Wood, Department of Pure and Applied Chemistry, University of Strathclyde, 295 Cathedral Street, Glasgow G1 1XL, Scotland.)

POLYMER CRYSTALS

September 21 - 24. 14th Europhysics Conference on Polymer Crystals—Structure and Morphology. Villafranca del Penedes, Spain.

(F. J. Balta Calleja, Instituto de Estructura de la Materia, Serrano, 119, Madrid 6, Spain.)

UPPER ATMOSPHERE PHYSICS

September 21 - November 12. Course and Workshop on Geomagnetism, The Ionosphere and Magnetosphere. Miramare-Trieste, Italy.

(International Centre for Theoretical Physics, POB 586, I-34100 Trieste, Italy.)

ZEOLITES

September 22 - 24. Metal Microstructures in Zeolites: Preparation, Properties & Applications. Bremen, Federal Republic of Germany.

(Prof. Dr. G. Schulz-Ekloff, Forschungsgruppe Angewandte Katalyse, Universitat Bremen, Fachbereich 3 - Chemie, Achterstrabe, D-2300 Bremen 33, Federal Republic of Germany.)

TRANSPORTATION OF CHEMICALS

September 26 - October 1. 7th International Symposium on the Transportation of Dangerous Goods by Sea and Inland Waterways. Vancouver, Canada.

(Mrs. Roxanne McDonald, Symposium Coordinator, 10th Floor, Pacific Plaza, 10909 Jasper Avenue, Edmonton, Alberta, Canada T5J 3M8.)

ADAPTION TO ENVIRONMENTAL CHANGE
September 26 - October 20. International Symposium on Plant, Animal and Microbial Adaptations to Terrestrial Environment. Halkidiki, Greece.

(Prof. N. S. Margaritis and Dr. M. Arianoutsou, Laboratory of Ecology, Faculty of Physics and Mathematics, University of Thessaloniki, UN. P.B. 119, Thessaloniki, Greece.)

MAGNETIC CIRCULAR DICHROISM

September 27 - 30. EUCHEM Conference on Magnetic Circular Dichroism. Belgium.

(Prof. C. Gorller-Walrand, Katholieke Universiteit te Leuven, Departement Scheikunde Afdeling Anorganische Analytische Scheikunde, Celestijnenlaan 200F 3030 Heverlee, Belgium.)

ION MOTION THROUGH MEMBRANES

September 27 - October 1. International Meeting of the Societe de Chimie Physique on Physical Chemistry of Transmembrane Ion Motions. Paris, France.

(Dr. C. Troyanowsky, General Secretary, Societe De Chimie Physique, 36th International meeting, 10, rue Vauquelin, F-75231 Paris Cedex 05, France.)

PERICYCLIC REACTIONS

September 27 - October 1. EUCHEM Conference on Pericyclic Reactions. Italy.

(Prof. A. Dondoni, Istituto Chimico, Universita of Ferrara, 44100 Ferrara, Via L. Borsari, Italy.)

WATER POLLUTION

October. Water Pollution Control Federation International Convention. Saint Louis, MO, USA.

(R. A. Canham, 3900 Wisconsin Avenue NW, Washington, DC 20016, USA.)

CONFERENCES 1982

THERMOPHYSICAL PROPERTIES

October 1 - 9. 8th European Conference on Thermophysical Properties. Baden-Baden, Federal Republic of Germany.
(H. E. Schmidt, 8 ETPC, Postfach 2266, D-7500, Karlsruhe, Federal Republic of Germany.)

CHEMICAL DATA

October 3 - 8. 8th International CODATA Conference. Kozubnik, Poland.
(Prof. A. Bylicki, Institute of Physical Chemistry, Polish Academy of Sciences, ul. Kasprzaka 44/52, 01 224 Warsaw, Poland.)

CHEMICAL REACTION ENGINEERING

October 4 - 6. International Symposium "Chemical Reaction Engineering". Boston, MA, USA.
(Prof. James Wei, Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, MA 02139, USA.)

PREVENTION OF AIR POLLUTION

October 4 - 8. International Colloquium on Prevention of Air Pollution. Strassburg, Austria.
(Verein Deutscher Ingenieure, VDI Presse- und Informationsstelle, 4 Dusseldorf 1, Postfach 1139, Federal Republic of Germany.)

RADIATION PROCESSING

October 4 - 8. 4th International Meeting on Radiation Processing. Dubrovnik, Yugoslavia.
(Dr. V. Markovic, Laboratory of Solid State Physics and Radiation Chemistry 030, Boris Kidric Institute of Nuclear Science, Vinca. POB 522, YU-11001 Belgrade, Yugoslavia.)

ENVIRONMENTAL POLLUTION

October 5 - 6. 3rd International Symposium on Environmental Pollution. Ontario, Canada.
(Alena Enterprises of Canada, 209 Dover Road, Cornwall, Ontario, Canada.)

ENVIRONMENTAL PROTECTION

October 6 - 8. Symposium on the Chemical Industry and the Environment in the 1980's. London, UK.
(The Conference Secretariat, Society of Chemical Industry (SCI) 14 Belgrave Square, London SW1X 8PS, UK.)

SPECTROSCOPY/CHROMATOGRAPHY

October 7 - 8. International Spectroscopy/Chromatography Conference. Ontario, Canada.
(Alena Enterprises of Canada, 209 Dover Road, Cornwall, Ontario, Canada.)

DEGRADATION OF POLYMERS

October 11 - 14. EUCHEM Conference on Degradation Processes in Natural Polymers. Netherlands.
(Dr. J. Lodewijks, c/o Central Research Laboratory of Art and Science, Gabriel Metsustraat 8, Amsterdam, The Netherlands.)

CHLORINATED DIOXINS

October 12 - 14. 3rd International Symposium/Workshop on Chlorinated Dioxins and Related Compounds. Salzburg, Austria.
(Dr. E. Merian, Im Kirsgarten 22, CH-4106 Therwil, Switzerland.)

PRECIOUS METALS

October 13 - 15. 6th International Conference on Precious Metals. Newport Beach, CA, USA.
(International Precious Metals Institute, Polytechnic Institute of New York, 333 Jay Street, Brooklyn, NY 11201, USA.)

MINERAL PROCESSING

October 17 - 23. 14th International Mineral Processing Congress. Toronto, Canada.
(L. J. Vincze, Publicity Chairman, XIV IMPC, 1194 Garden Road, Mississauga, Ontario L5H 3J6, Canada.)

CHEMICALS IN THE ENVIRONMENT

October 18 - 20. Conference on Chemicals Testing and Hazard Ranking—the Interaction between Science and Administration. Lyngby, Copenhagen, Denmark.
(Conference Secretariat: DIS Congress Service, Linde Alle 48, DK-2720 Vanlose, Copenhagen, Denmark.)

CORROSION

October 18 - 22. Conference of the European Federation for Corrosion (EUROCORR '82). Budapest, Hungary.
(Scientific Society of Mechanical Engineers, P.O. Box 451, H-1372 Budapest, Hungary.)

EQUIPMENT MAINTENANCE

October 18 - 22. 3rd International Conference on Reliability and Maintainability. Toulouse, France.
(Centre National D'Etudes Spatiales, Département des Affaires Universitaires, 18, avenue Edouard-Belin, 31055 Toulouse Cedex, France.)

THERMOCHEMICAL BIOMASS CONVERSION

October 18 - 22. International Conference on Fundamentals of Thermochemical Biomass Conversion. CO, USA.
(Zo Milne, Solar Energy Research Institute, 1617 Cole Blvd., Golden, CO 80401, USA.)

PYRIDINE CHEMISTRY

October 21. Symposium on Pyridine Chemistry: New Synthetic Methods & Industrial Applications. Indianapolis, USA.
(W. K. Fife, Department of Chemistry, IUPUI, 1201 East 38th St., P.O. Box 647, Indianapolis, IN 46223, USA.)

ANALYTICAL MS TECHNIQUES

October 21 - 22. 2nd Workshop and Exhibition on Liquid Chromatography/Mass Spectrometry and Mass Spectrometry/Mass Spectrometry. Montreux, Switzerland.
(Workshop Office, Dr. Alain Donzel, Case postale 5, CH-1052 Le Mont-sur Lausanne, Switzerland.)

LASER-GENERATED PLASMAS

October 25 - 29. 6th International Workshop on Laser Interaction and Related Plasma Phenomena. Monterey, CA, USA.
(Prof. George H. Miley, Fusion Studies Laboratory, 214 Nuclear Engineering Laboratory, University of Illinois, 103 South Goodwin Avenue, Urbana, IL 61801, USA.)

LIQUID CRYSTALS

October 27 - 28. Discussion Meeting on The Physics, Chemistry and Applications of Liquid Crystals. London, UK.
(Miss C. A. Johnson, The Royal Society 6 Carlton House Terrace, London SW1Y 5AG, UK.)

ENVIRONMENT AND RADIATION PROTECTION

November 2 - 7. 1st World Congress on Environment and Radiation Protection. Vienna, Austria.
(Dr. Szentgaly Suri Arpad, Institut fur Umweltschutz und Strahlendatin-Sammlung, Kirchengasse 32, A-1070, Vienna, Austria.)

CONFERENCES 1982/83

HIGH TEMPERATURE CORROSION

November 17 - 20. 3rd International Symposium on High Temperature Corrosion of Metals and Alloys. Tokyo, Japan.
(Japan Institute of Metals, Aza Aoba Aramaki, Sendai-shi Miyagi 980, Japan.)

PHOTOCHEMISTRY & PHOTOGRAPHY

November 22 - 25. 11th Symposium on Photochemistry—Fotografia Academica 82, Photophysics and Scientific Photography. Pardubice, Czechoslovakia.
(Dip.-Ing, Vlastimil Rusek, Fotografia Academia Vscht TP Doubravice, 533 53 Semtin Czechoslovakia.)

CHEMISTRY RELATING TO AGRICULTURE

December 6 - 10. Chemical Research to Meet the World's Expanding Food Needs (CHEMRAWN II). Manila, Philippines.

(Dr. Charles S. Dennison, Executive Director, Council on Science & Technology for Development, 2010 Massachusetts Avenue NW, Washington, DC 20036, USA.)

See additional information in this issue.

HAZARDOUS SUBSTANCES IN THE ATMOSPHERE

December 20 - 22. International Conference. The Detection and Measurement of Hazardous Substances in the Atmosphere. The City University, London, UK.

(Dr. John F. Gibson, The Royal Society of Chemistry, Burlington House, London W1V 0BN, UK.)

RETRAINING OF SCIENCE TEACHERS

December 27 - 31. 4th ICASE - ASIAN Symposium on Updating and Retraining of Science Teachers. Hong Kong.

(Symposium Organiser, 4th ICASE - ASIAN Symposium, c/o Hkasme, Diocesan Boy's School, 131 Argyle Street, Mongkok, Kowloon, Hong Kong.)

1983

ORGANIC FREE RADICALS

EUCHEM Conference on Organic Free Radicals. Federal Republic of Germany.

(Prof. R. Sustman, Universitat Essen-Gesamthochschule, Universitätsstrasse 2, Postfach 6843, 4300 Essen, Federal Republic of Germany.)

COMPUTERS IN CHEMISTRY

EUCHEM Conference on Computers in Chemistry from Conception to Production. France.

(Dr. M. Le Grand, Centre de Recherche, Roussel Uclaf, 102 Route de Noisy, 93 Romain ville, France.)

LASERS IN SPECTROSCOPY

January 24 - March 25. 5th International Course on Atomic and Molecular Physics. Laser principles and techniques, applications to spectroscopy, topics in atomic and molecular physics, applications of short laser pulses in Physics, Chemistry and Biology. Miramare Trieste, Italy.

(International Centre for Theoretical Physics, POB 586, I-34100 Trieste, Italy.)

MASS SPECTROMETRY

February 7 - 11. 8th Conference of the Australian and New Zealand Society for Mass Spectrometry. Melbourne, Australia.

(Secretary, ANZSMS Conference, Chemistry Department, Monash University, Clayton, Victoria, Australia.)

OILS, FATS & WAXES

February 13 - 17. International Conference on Oils, Fats & Waxes. Auckland, New Zealand.

(Mr. S. G. Brooker, Department of Chemistry, University of Auckland, Private Bag, Auckland, New Zealand.)

HYDRAULIC CEMENTS

February 16 - 17. Discussion Meeting on Technology in the 1990s: Developments in the Science and Technology of Hydraulic Cements. London, UK.

(Miss C. A. Johnson, The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG, UK.)

COOPERATIVE EDUCATION

February 21 - 25. World Conference on Cooperative Education. Melbourne, Australia.

(The Chairman, World Conference on Cooperative Education, POB 218, Hawthorn 3122, Australia.)

WATER TECHNOLOGY

March 1 - 4. International Water Technology Exhibition and Conference—AguaMex '83. Mexico City.

(Ian North, World Water P.O. Box 101, 26 Old Street, London EC1, UK, or Denise Smith, Bryant and Associates Inc. 2650 Fountainview, Suite 120, Houston, TX 77057, USA.)

METALLIC CORROSION

March 2 - 3. Symposium on Prevention of Metallic Corrosion "An Element of a Raw Materials and Energy Conservation Policy". Luxemburg.

(C. Cabrillac, CEFRAFOR, 28 rue Saint-Dominique, F-7500 Paris, France.)

ESSENTIAL OILS

March 13 - 17. 9th International Congress of Essential Oils. Singapore.

(9th International Congress of Essential Oils, Suite 1106, World Trade Centre, No. 1 Maritime Square, Singapore 0409.)

AMERICAN CHEMICAL SOCIETY

March 20 - 25. 185th ACS National Meeting. Seattle, USA.

(A.T. Winstead, ACS, 1155 — 16th St. NW, Washington, DC 20036, USA.)

AGRICULTURAL RESEARCH

March 21 - 25. CSIRO International Symposium on Agricultural Research for Tropical North-Western Australia. Darwin, Australia.

(Symposium Secretary, Division of Tropical Crops and Pastures, Charles Darwin Laboratories, Darwin, NT, Australia.)

CORROSION '83

March 21 - 26. Corrosion '83 International Conference. Anaheim, CA, USA.

(Conference Co-ordinator, National Association of Corrosion Engineers, PO Box 218340, Houston, TX 77218, USA.)

CHEM/ASIA

April. 3rd General Assembly and 2nd Regional Seminar of the Federation of Asian Chemical Societies. Baghdad, Iraq.

(Dr. M. M. Singh, Rubber Research Institute of Malaysia, P.O. Box 150, Kuala Lumpur, Malaysia.)

CONFERENCES 1983

EFFLUENT TREATMENT

April. Symposium on Effluent Treatment in the Process Industries. Loughborough, UK.
(Dr. J. J. Stenhouse, Department of Chemical Engineering, University of Technology, Loughborough, UK.)

LASER CHEMISTRY

April. EUCHEM Conference on Laser Chemistry. Belgium.
(Prof. X de Hemptinne, Katholieke Universiteit te Leuven, Laboratorium voor Fysico chemie en Kinetica, Celestijnenlaan 200F, 3030 Heverlee, Belgium.)

ELECTROANALYSIS

April 5 - 8. International Symposium on Electroanalysis in Biomedical, Environmental and Industrial Sciences. Cardiff, Wales.
(Dr. J. D. R. Thomas, UWIST, Department of Chemistry, King Edward VII Avenue, Cardiff CF1 3NU, Wales.)

CRYOGENICS

April 7 - 12. International Conference on Cryogenic Fundamentals. Wroclaw, Poland.
(B. Stalinski, Institute for Low Temperature and Structure Research, Polish Academy of Sciences, pl. Katedrainy 1, PL-50 350 Wroclaw, Poland.)

CHEMICAL ENGINEERING

April 11 - 13. 6th International Congress in Scandinavia on Chemical Engineering. Copenhagen, Denmark.
(Bella Center A/S, Center Boulevard, DK-2300 Copenhagen, Denmark.)

WATER TREATMENT

April 11 - 15. 1983 National Conference on Australian Water and Wastewater Association. Australia.
(1983 National Conference Secretary, P.O. Box A232, Sydney South, NSW 2000, Australia.)

RADIATION SOURCES

April 18 - 21. 3rd International Symposium on the Science and Technology of Light Sources.
(J. J. Damelincourt, Centre de Physique Atomique, Universite Paul Sabatier, 118 route de Narbonne, F-31062 Toulouse Cedex, France.)

SCIENCE/SOUTH PACIFIC

May. 53rd Conference of the Australian & New Zealand Association for the Advancement of Science. Perth, Australia.
(ANZAAS, Box 873, GPO, Sydney 2001, Australia.)

LIQUID CHROMATOGRAPHY

May 1 - 6. 7th International Symposium on Column Liquid Chromatography. Baden-Baden, Federal Republic of Germany.
(Gesellschaft Deutscher Chemiker, Abteilung Fachgruppen, Postfach 90 04 40, D-6000 Frankfurt/-Main 90, Federal Republic of Germany.)

WATER DESALINATION

May 23 - 27. 1st World Congress on Desalination and Water. Reuse, Florence, Italy.
(DECHEMA, Attn: Mrs. L. Schubel, P.O.B. 97 01 46, D-6000 Frankfurt 97, Federal Republic of Germany.)

CORROSION

May 30 - June 2. 4th International Symposium on Corrosion in the Pulp & Paper Industry. Stockholm, Sweden.
(Swedish Corrosion Institute, Box 5607, S-11468, Stockholm, Sweden.)

CHROMATOGRAPHIC DETECTORS

May 30 - June 3. International Conference on Chromatographic Detectors. Melbourne, Australia.
(The Secretary, International Conference on Chromatographic Detectors, University of Melbourne, Parkville, Victoria 3052, Australia.)

RING-OPENING REACTIONS

June. EUCHEM Conference on Synthetic uses of Ring-opening Reactions of Aromatic Heterocycles. Sweden.
(Prof. Sal Gronowitz, Department of Organic Chemistry 1, Chemical Centre, University of Lund, POB 740, S-220 07 Lund, Sweden.)

IUPAC CONGRESS

June 4 - 12. 29th International Congress of Pure & Applied Chemistry. Cologne, Federal Republic of Germany.
(General Secretariat of the 29th IUPAC Congress, Dr. W. Fritsche, c/o Gesellschaft Deutscher Chemiker, P.O. Box 900440, D-6000 Frankfurt/M 90, Federal Republic of Germany.)

POLYMER SCIENCE

June 6 - 9. Milestones and Trends in Polymer Science: A Tribute to Turner Alfrey. Midland, MI, USA.
(Dr. James K. Rieke, 1702 Building, Dow Chemical Company, Midland, MI 48640, USA.)

DRUG ANALYSIS

June 7 - 10. 1st International Symposium on Drug Analysis. Brussels, Belgium.
(Ms. C. Van Kerchove (Secretary), Societe Belge des Sciences Pharmaceutiques—Belgisch Genootschap voor Pharmaceutische Wetenschappen, rue Archimedesstraat 11, B-1040 Brussels, Belgium.)

POLYETHYLENE

June 8 - 10. Golden Jubilee Conference "Polyethylenes 1933 - 1983: Past, Present and Future". London, UK.
(J. N. Ratcliffe, Secretary General, The Plastics and Rubber Institute, 11, Hobart Place, London SW1W 0HL, UK.)

SEMICONDUCTOR DEVICES

June 15 - 17. 3rd International Conference on the Numerical Analysis of Semiconductor Devices and Integrated Circuits. Galway, Ireland.
(NASECODE Conference, 39 Trinity College, Dublin 2, Ireland.)

DIFFUSION & FLUID FLOW

June 16 - 18. 2nd International Conference on Boundary and Interior Layers—Computational and Asymptotic Methods. Dublin, Ireland.
(BAIL Conference, 39 Trinity College, Dublin 2, Ireland.)

ZIRCONIA TECHNOLOGY

June 21 - 23. 2nd International Conference in the Science and Technology of Zirconia (ZIRCONIA-83). Stuttgart, Federal Republic of Germany.
(Nils Claussen, Max-Planck-Institut für Metallforschung, Institut für Werkstoffwissenschaften, Heisenbergstrabe 5, D-700 Stuttgart 80, Federal Republic of Germany.)

SPECTROSCOPY

June 26 - July 1. 23rd Colloquium Spectroscopicum Internationale. Amsterdam, The Netherlands.
(23rd CSI, c/o Organisatie Bureau Amsterdam BV, Europaplein, 1078 GZ Amsterdam, The Netherlands.)

CONFERENCES 1983

ELECTRON MICROSCOPY

Summer. EUCHEM Conference on High Resolution Electron Microscopy in Solid State Chemistry. Sweden.

(Prof. L. Kihlberg, Department of Inorganic Chemistry, Arrhenius Laboratory, University of Stockholm, S-106 91 Stockholm, Sweden.)

ATOMIC SPECTROSCOPY

July. 15th Conference of the European Group for Atomic Spectroscopy. Saragossa, Spain.

(Mr. E. Bernabeu, The University E-Saragossa, Spain.)

RADIATION RESEARCH

July 3 - 8. 7th International Congress of Radiation Research. Amsterdam, Netherlands.

(J. J. Broerse, Secretary General, 7th International Congress of Radiation Research, c/o Radiobiological Institute TNO, POB 5815, 2280 HV Rijswijk, The Netherlands.)

SOLID STATE IONICS

July 4 - 8. 4th International Conference on Solid State Ionics. Grenoble, France.

(M. Kleitz, SSI 83, ENSEEG, B.P. 44, F-38401 Saint Martin d'Heres, France.)

MONOCLONAL ANTIBODIES

July 6 - 9. International Association of Biological Standardization on Monoclonal Antibodies: Standardization in their Production and Use. Paris, France.

(Dr. M. Barme, Institut Pasteur, 25 rue du Dr. Roux, F-75015 Paris, France.)

SMOKING AND HEALTH

July 10 - 15. 5th World Conference on Smoking and Health. Winnipeg, Canada.

(5th World Conference on Smoking and Health, P.O. Box 228, Station B, Ottawa, Ontario, Canada K1P 6C4.)

PROPERTIES OF COPOLYMERS

July 11 - 14. 24th Prague Microsymposium: Copolymers, Structure and Solution Properties. Prague, Czechoslovakia.

(Dr. P. Kratochvíl, c/o, Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského nám. 2, 162 06 Prague 616, Czechoslovakia.)

BORON CHEMISTRY

July 11 - 15. Imeboron V (Organic and Inorganic). Swansea, Wales.

(Prof. A. Pelter, Department of Chemistry, University College of Swansea, Singleton Park, Swansea, West Glamorgan SA2 8PP, Wales.)

ANALYTICAL CHEMISTRY

July 17 - 23. SAC 83 Conference and Exhibition, organised by the Analytical Division of the Royal Society of Chemistry. University of Edinburgh, Edinburgh, Scotland.

(Dr. J. M. Ottaway, Department of Pure & Applied Chemistry, University of Strathclyde, Cathedral Street, Glasgow G1 1XL, Scotland.)

POLYMER STABILITY & PROCESSING

July 18 - 21. 25th Prague Microsymposium: Processing and Long-Term Stabilities of Hydrocarbon Polymers. Prague, Czechoslovakia.

(Dr. J. Pospisil, c/o, Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského n. 2, 162 06 Prague 616, Czechoslovakia.)

TOXICOLOGY OF METALS

July 20 - 23. 2nd International Symposium on Clinical Chemistry and Chemical Toxicology of Metals. Montreal, Canada.

(Dr. J. Savory, University of Virginia Medical Center, Department of Pathology, Box 168, Clinical Laboratories, Charlottesville, VA 22908, USA.)

ANALYTICAL CHEMISTRY

August. 7th Analytical Chemistry Division Symposium of the Royal Australian Chemical Institute. Adelaide, Australia.

(K. J. Heinrich, Forensic Science Centre, Divett Place, Adelaide 5000, Australia.)

CRYSTALLOGRAPHY

August. 8th European Crystallographic Meeting. Liège, Belgium.

(Prof. J. Toussaint, Institut de Physique B5, Université de Liège au Sart-Tilman, B-4000 Liège, Belgium.)

THEORETICAL CHEMISTRY

August 7 - 12. 8th Canadian Symposium on Theoretical Chemistry. Halifax, Nova Scotia, Canada.

(Dr. R. J. Boyd, Department of Chemistry, Dalhousie University, Halifax, Nova Scotia B3H 4J3, Canada.)

FOOD TOXINS

August 12 - 15. Symposium on Mycotoxins. Sydney, Australia.

(Dr. John Lacey, Department of Plant Pathology, Rothamsted Experimental Station, Harpenden, Herts. AL5 2JQ, UK.)

NATURAL PRODUCTS

August 15 - 19. 2nd International Conference on Chemistry and Biotechnology of Biologically Active Natural Products. Budapest, Hungary.

(G. Kovacs, Chinoin Pharm. Che. Works, H-1325 Budapest, POB 110, Hungary.)

IUPAC GENERAL ASSEMBLY

August 18 - 26. 32nd IUPAC General Assembly. Lyngby, Copenhagen, Denmark.

(IUPAC Secretariat, 2 - 3 Pound Way, Cowley Centre, Oxford OX4 3YF, UK.)

CHEMICAL EDUCATION

August 21 - 26. 7th International Conference on Chemical Education: "Chemistry Education and Society". Montpellier, France.

(Pr. M. Chastrette, Laboratoire de Chimie Organique Physique, Université Lyon I, 43, Bld du 11 Novembre 1918, 69622 Villeurbanne, France.)

HETEROCYCLIC CHEMISTRY

August 21 - 26. 9th International Congress of Heterocyclic Chemistry. Tokyo, Japan.

(Yuichi Kanaoka, Faculty of Pharmaceutical Sciences, Hokkaido University Sapporo, 060 Japan.)

SOLVENT EXTRACTION

August 26 - September 2. International Solvent Extraction Conference. Denver, CO, USA.

(ISEC '83, American Institute of Chemical Engineers, 345 East 47th Street, New York, NY 10017, USA.)

ORGANOMETALLIC CHEMISTRY

August 28 - September 1. 2nd IUPAC Symposium on Organometallic Chemistry directed toward Organic Synthesis. Dijon, France.

(Prof. J. Tirouflet, Université de Dijon, Boite Postale 138, 21004 Dijon Cedex, France.)

CONFERENCES 1983

AMERICAN CHEMICAL SOCIETY

August 28 - September 2. 186th National Meeting of the American Chemical Society. Washington DC, USA.

(A. T. Winstead, American Chemical Society, 1155 16th Street NW, DC 20036, USA.)

MICROCHEMICAL TECHNIQUES

August 28 - September 2. ISM'83, 9th International Symposium on Microchemical Techniques. Amsterdam, The Netherlands.

(Municipal Congress Bureau, Oudezijds Achterburgwal 199, 1012 DK Amsterdam, The Netherlands.)

FUNGI

August 28 - September 3. 3rd International Mycological Congress. Tokyo, Japan.

(Prof. K. Tubaki, Institute of Biological Sciences, University of Tsukuba, Sakura-Mura, Ibaraki 300-31, Japan.)

IONIZED GASES

August 29 - September 3. 16th International Conference on Phenomena in Ionized Gases. Dusseldorf, Germany.

(Dr. W. Böttcher, Institut f. Plasmaphysik, Callingstr. 38, D-3000 Hannover, Federal Republic of Germany.)

CATIONIC POLYMERIZATION

August 30 - September 2. 6th International Symposium on Cationic Polymerization and Related Processes. Belgium.

(Prof. E. Goethals, Institute of Organic Chemistry, Rijksuniversiteit-Gent, Krijgslaan 281 (S-4) B-9000 Ghent, Belgium.)

ON-LINE MONITORING

August 31 - September 2. 1st International Conference on On-Line Surveillance and Monitoring ("ICOSM 83"). London, UK.

(ICOSM '83 c/o The Conference Secretariat, Society of Chemical Industry, 14/15 Belgrave Square, London SW1X 8PS, UK.)

POLYMERIZATION OF HETEROCYCLES

September. International Symposium on Polymerization of Small Heterocycles and Aldehydes. Poland.

(Prof. Z. Jedliński, Polish Academy of Sciences, Polymer Institute, POB 49, Curie - Skłodowskiej 34, PL - 41 800 Zabrze, Poland.)

GEOCHEMICAL EXPLORATION

September. 10th International Geochemical Exploration Symposium. Helsinki, Finland.

(L. K. Kauranne, Organizing Committee, 10th IGES., The Geological Survey of Finland, Kivimiehentie 1, 02150 Espoo 15, Finland.)

FOURIER TRANSFORM SPECTROSCOPY

September 5 - 9. International Conference on Fourier Transform Spectroscopy. Durham, UK.

(J. R. Birch, Division of Electrical Science, National Physical Laboratory, Teddington, Middlesex TW11 0LW, UK.)

MACROMOLECULES

September 5 - 9. 29th International Symposium on Macromolecules. Bucharest, Romania.

(Acad. Cristofor Simionescu, Institutul de Chimie Macromoleculara Petru Poni Aleea Grigore Ghica Voda Nr.41A, Iasi, Romania.)

ORGANIC CHEMISTRY

September 5 - 9. 3rd European Symposium on Organic Chemistry. University of Kent, Canterbury, UK.

(Prof. R. F. Hudson, University of Kent at Canterbury, Kent CT2 7NH, UK.)

PHOSPHORUS CHEMISTRY

September 5 - 9. International Conference on Phosphorus Chemistry. Nice, France.

(Prof. J. G. Riess, Laboratoire de Chimie Minérale Moléculaire, Université de Nice, Parc Valrose, 06034 Nice, France.)

CRYSTAL GROWTH

September 12 - 16. 7th International Conference on Crystal Growth. Stuttgart, Federal Republic of Germany.

(Prof. Dr. M. Pilkuhn, Universität Stuttgart, Pfaffenwaldring 57, 7000 Stuttgart 80, Federal Republic of Germany.)

FOOD TECHNOLOGY

September 18 - 23. 6th World Congress of Food Science and Technology. Dublin, Ireland.

(Dr. R. L. Joseph, c/o An Foras Taluntais, Dun-sinea, Castleknock, Co. Dublin, Ireland.)

ENERGY RESOURCES

September 19 - 23. 12th World Energy Conference. New Delhi, India.

(E. Ruttle, World Energy Conference, 34 St. James' Street, London SW1A 1HD, UK.)

MOSSBAUER EFFECT

September 19 - 24 (or September 26 - October 1). International Conference on the Applications of Mossbauer Effect. Alma-Ata, USSR.

(Dr. V. Ya. Rochev, Institute of Chemical Physics, Academy of Sciences of the USSR, Ulitsa Kossygina, 4, Moscow 117334, USSR.)

DRUG ABSORPTION

September 21 - 23. 2nd International Conference on Drug Absorption: Rate Control in Drug Therapy. Edinburgh, Scotland.

(Secretariat, 2nd International Conference on Drug Absorption, Centre for Industrial Consultancy and Liaison, University of Edinburgh, 16 George Square, Edinburgh EH8 9LD, Scotland.)

POTASH TECHNOLOGY

October 3 - 5. 1st International Potash Technology Conference. Saskatoon, Saskatchewan, Canada.

(Miss Joyce Lubenow, Conference Secretary, c/o SEDCO, 241 Second Avenue South, Saskatoon, Saskatchewan S7K 1K8, Canada.)

CORROSION PROTECTION

October 9 - 14. Joint Symposium on Fundamental Aspects of Corrosion Protection by Surface Modification. Washington DC, USA.

(R. P. Frankenthal, Chairman, Corrosion Division of Electrochemical Society, c/o Bell Laboratories, 600 Mountain Avenue, Murray Hill, NY 07974, USA.)

ENVIRONMENTAL BIOGEOCHEMISTRY

October 9 - 14. 6th International Symposium on Environmental Biogeochemistry. Sante Fe, NM, USA.

(Douglas Caldwell, Department of Biology, University of New Mexico, Albuquerque, NM 87131, USA.)

1984

CHEMICAL RESOURCES OF THE OCEAN CHEMRAWN IV—Chemistry and Resources of the Oceans. MA, USA.

(J. Robert Moore, Director, Marine Science Institute, The University of Texas, Austin, TX 78712, USA.)

CHEM/ASIA

January. 2nd Chemical Congress of the Federation of Asian Chemical Societies. India.

(Dr. M. M. Singh, Rubber Research Institute of Malaysia, P.O. Box 150, Kuala Lumpur, Malaysia.)

CORROSION

April 1 - 6. Corrosion '84 International Conference. New Orleans, LA, USA.

(Conference Co-ordinator, National Association of Corrosion Engineers, POB 218340, Houston, TX 77218, USA.)

MINERAL PROCESSING

April 2 - 5. International Conference on Recent Advances in Mineral Science and Technology (MINTECH 50). Johannesburg, South Africa.

(Conference Secretariat, National Institute for Metallurgy, Private Bag X3015, 2125 Randburg, Republic of South Africa.)

EXTRACTIVE METALLURGY

April 2 - 13. International Conference on Recent Advances in Extractive Metallurgy. Johannesburg, South Africa.

(Conference Secretariat, National Institute for Metallurgy, Private Bag X3015, 2125 Randburg, Republic of South Africa.)

AMERICAN CHEMICAL SOCIETY

April 8 - 13. 187th National Meeting of the American Chemical Society. MI, USA.

(A. T. Winstead, American Chemical Society, 1155 16th Street NW, DC 20036, USA.)

BIOMATERIALS

April 26 - May 1. 2nd World Congress on Biomaterials. Washington DC, USA.

(Dr. S. R. Pollack, Department of Bioengineering, 285 Town Building D3, University of Pennsylvania, Philadelphia, PA 19104, USA.)

SCIENCE/AUSTRALASIA

May. 54th ANZAAS Conference. Canberra, Australia.

(ANZAAS, Box 873, GPO Sydney 2001, Australia.)

METALLIC CORROSION

June 3 - 7. 9th International Congress on Metallic Corrosion (ICMC). Toronto, Canada.

(Mrs. L. Bagnée, Executive Secretary, 9th ICMC, c/o National Research Council, Ottawa K1A 0R6, Canada.)

PRECIOUS METALS

June 3 - 7. 8th International Conference on Precious Metals. Toronto, Canada.

(International Precious Metals Institute, Polytechnic Institute of New York, 333 Jay Street, Brooklyn, NY 11201, USA.)

CHEMRAWN III

June 25 - 29. CHEMRAWN III. Amsterdam.

(Ir. E. J. de Ryck van der Gracht, Executive Secretary, Royal Netherlands Chemical Society, Burnierstraat 1, 2596 HV Den Haag, Netherlands.)

CATALYSIS

July 2 - 6. 8th International Congress on Catalysis. Berlin, Federal Republic of Germany.

(DECHEMA, P. O. Box 970146, D-6000 Frankfurt am Main 97, Federal Republic of Germany.)

NATURAL PRODUCTS

July 9 - 14. 14th International Symposium on the Chemistry of Natural Products. Poznan, Poland.

(Prof. dr. Maciej Wiewiorowski, Institute of Bioorganic Chemistry, Polish Academy of Sciences, ul. Noskowskiego 12/14, 61-704 Poznan, Poland.)

ORGANIC CHEMISTRY

August. 7th IUPAC Conference on Physical Organic Chemistry. Auckland, New Zealand.

(Conference Secretary, Professor B. R. Davis, Chemistry Department, University of Auckland, Private Bag, Auckland, New Zealand.)

CRYSTALLOGRAPHY

August 9 - 18. 13 General Assembly and International Congress of Crystallography. Hamburg, Federal Republic of Germany.

(Dr. J. N. King, Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, UK.)

AMERICAN CHEMICAL SOCIETY

August 26 - 31. 188th Meeting of the American Chemical Society. PA, USA.

(A. T. Winstead, American Chemical Society, 1155 16th Street NW, DC 20036, USA.)

RAMAN SPECTROSCOPY

August 26 - September 1. 9th International Conference on Raman Spectroscopy. Japan.

(Prof. Mitsuo Tasumi, Department of Chemistry, Faculty of Science, The University of Tokyo, Bunkyo-ku, Tokyo 113, Japan.)

FORENSIC SCIENCE

September 18 - 25. 10th Conference of the International Association of Forensic Sciences. Oxford, UK.

(Forensic Science Society, P.O. Box 41, Harrogate, N. Yorks HG1 1QL, UK.)

BIOTECHNOLOGY

November/December. 7th International Biotechnology Symposium. New Delhi, India.

(Prof. T. K. Ghose, Chairman, National Organisation Committee & Head, Biochemical Engineering Research Centre, Indian Institute of Technology, Hauz Khas, New Delhi-110029, India.)

AMERICIUM AND CURIUM CHEMISTRY

December 16 - 22. International Symposium on Americium and Curium Chemistry and Technology. Honolulu, Hawaii, USA.

(Dr. James D. Navratil, Rockwell International, Rocky Flats Plants, P.O. Box 464, Golden, CO 80401, USA.)

CHEMISTRY/PACIFIC BASIN

December 16 - 22. International Congress of Pacific Basin Societies. Honolulu, Hawaii. (A. T. Winstead, ACS, 1155 16th St. NW, Washington, DC 20036, USA.)

Chemistry International

is the news magazine of the

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The International Union of Pure and Applied Chemistry (IUPAC), formed in 1919, is a voluntary, non-governmental, non-profit association of organizations, each of which represents the chemists of a member country.

Its objectives are:

to promote continuing co-operation among the chemists of the member countries;

to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;

to co-operate with other international organizations which deal with topics of a chemical nature;

to contribute to the advancement of pure and applied chemistry in all its aspects.

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of Pure and Applied Chemistry (IUPAC)



TEACHING AND RESEARCH AT
THE OPEN UNIVERSITY



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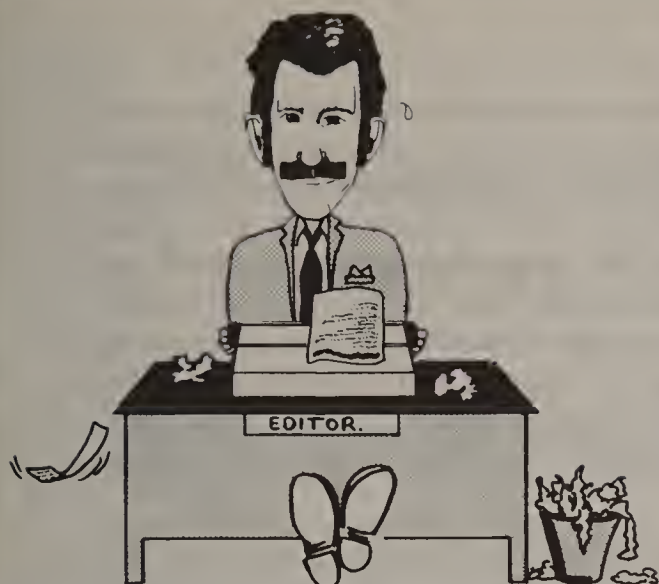
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THE EDITOR'S DESK

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The cost of chemistry

Chemistry, being an experimental science, is an expensive subject to teach. It requires laboratories, equipment, stockroom personnel and chemicals. The price of chemical equipment and reagents has been spiraling upwards faster than the general rate of inflation, imposing a price squeeze on chemistry departments (whose budgets have been held essentially constant or reduced). Department members who try to explain the rapid rise in chemical and equipment costs are often met with scepticism or disbelief.

In order to demonstrate to administrators and education authorities how much their budgets have been eroded by price increases, one chemistry faculty member (Dennis Tuck at the University of Windsor in Ontario, Canada) proposed that a "Chemical Cost-of-Living Index" be compiled in each country. He described, in an article in the May 1982 issue of *Chemistry in Canada*, how his department compiled such indexes for common chemicals, research chemicals, materials and supplies of minor apparatus (glassware). They concluded that, in all categories, there had been an approximately three-fold increase in costs between 1974 and 1981. Every item included in the price survey (including about 25 chemicals commonly used in teaching and research laboratories; supplies such as pump oil, copper wire and chart paper; and various types of equipment) had increased sharply in cost during this period.

In discussing the choice of chemicals and apparatus used in his survey, Dr. Tuck touched upon the main limitations of a "Chemical Cost-of-Living Index", and hinted at a way to cope with escalating costs. By compiling a cost-of-chemical index, he implicitly assumes that university laboratories use the same chemicals—in the same amounts—as they did some 8 years ago. However, it is doubtful that they do, and even more doubtful that they should. In the past, little thought was given to cost or safety considerations when selecting experiments. Many of the experiments being performed now in university teaching laboratories are identical to those performed 30 years ago, although thousands of other interesting experiments and demonstrations are described in the chemical literature. Silver nitrate is still used in undergraduate chemistry experiments (to analyze halide ions), although as Dr. Tuck notes, the purchase of this compound consumes a disproportionately large share of the budget for chemicals. Are there not other experiments using cheaper reagents, that could teach the same principles and techniques as effectively?

Perhaps chemistry faculties should reconsider each experiment being performed in their laboratories. Is it really effective in demonstrating an important concept or laboratory technique? Are the reagents excessively expensive? Does it require expensive equipment that cannot be used for other experiments? And most important of all, is it safe? All chemicals can be dangerous, but some are much more dangerous than others. *Check* the hazards associated with each chemical used in the experiment. Does your laboratory have adequate fume hoods and other safety equipment, and do the students have sufficient knowledge and experience to safely handle the chemicals you want them to use? Experiments that use highly toxic, flammable or expensive chemicals are best avoided — even if your laboratory has the equipment or the money to use them.

In this issue, we discuss some of the dangers posed by common chemicals, and we also describe novel teaching methods (particularly television) that allow students to see experiments using sophisticated equipment, and expensive or hazardous reagents. They augment regular laboratory work and give the student some experience that he otherwise would not (and probably should not) get in the chemical laboratory.

LETTERS

More on atomic weights

The controversy about whether the term "atomic weight" should be replaced has led to a snowballing influx of letters. The Editor had thought that the discussion in previous issues of Chemistry International ("A new concept alters the way chemists view atomic weights" in Issue No. 4, 1980 and letters in Issue No. 2, 1982) had exhausted the subject. Rather, this subject is exhausting the Editor! Here is an extract of recent letters.

Professor Freeman correctly points out (*Chemistry International*, 1982, No. 2, p.8) that the atomic mass of H is 1.008 u (atomic weight units), but he states that the molar mass of H is 1.008 grams. In fact the molar mass is 1.008 grams/mol according to the *IUPAC Manual of Symbols and Terminology for Physicochemical Quantities and Units*.

In his comment, the Editor seeks to persuade Professor Freeman that the use of 'molar mass' should eliminate the need for statements of 'molecular mass'. Let us not take sides on this, but use whichever quantity is convenient for our purpose. A great advantage of 'molar mass' is that its units appear in calculations and allow checking of their dimensions.

Since the atomic mass unit has a cumbersome name and a bizarre symbol (u), I would point to the

biochemists' practice, approved by IUB and submitted to IUPAC, of allowing it to be called the 'dalton' (symbol: Da). Calibrations of scales of molecular mass in Da, kDa, or MDa are largely self-explanatory.

H. B. F. Dixon
Secretary, IUPAC - IUB Joint
Commission on Biochemical Nomenclature

There is no doubt that the dimension of a molar mass is mass (amount of substance)⁻¹ and the SI unit is kg mol⁻¹ and multiples thereof. *Not* grams.

Prof. D. H. Whiffen, Member
IUPAC Commission on Physicochemical
Symbols and Terminology

Like your correspondents Robert Freeman and Norman Holden, I hold views on the issues raised in *Chemistry International* (1980, No.4, pp. 9 - 10). There are several points at issue:

- How do we define atomic weight?
- Do we need another (non-SI) unit for it?
- What should we call it?

My own concern arose from needs in expressing data about colloidal particles and viruses, where the names atomic and molecular weight are inappropriate. Two problems arise if atomic weight is treated as dimensionless. The first represents the difference in scale between old and new atomic weights,

Continued on page 19

The deadly nature of common chemicals

After years of working in the laboratory, chemists tend to become complacent about the chemical reagents and solvents lining their shelves and walls. They periodically add new bottles amongst the rusty tins and jars with faded labels. Many were probably used years ago, perhaps by a previous employee working on experiments long since forgotten. Most are quite ordinary and seemingly innocuous; perhaps some sodium hydroxide, a bottle of benzene, some chromic acid cleaning solution. Such chemicals comprise a backdrop in the life of the chemist, ever-present but rarely noticed.

These very chemicals that form such an integral part of our lives also have the capability to kill or injure us. Although relatively small amounts of materials are usually stored or handled in the laboratory, the dangers they pose are frequently underestimated. Indeed, familiarity instills a false sense of confidence. Few realize the frightening speed with which chemical burns, poisoning or fires can develop and lead to tragedy. A chemist working in the laboratory is literally surrounded by hazards. Should he drop a reagent bottle, he could be drenched with a corrosive liquid, exposed to acute or chronic levels of toxic fumes, or face a fire that could rapidly engulf the laboratory in a raging inferno. The chemist might even face all three predicaments simultaneously!

Such situations are not hypothetical. They happen, and they sometimes kill, disable or blind the individuals involved. Other accidents inflict pain and disfiguring scars. Discussing and examining such incidents is one important aspect of a two-day *Hazardous Chemicals Safety Seminar* organized by the J. T. Baker Chemical Company. In preparing the course material, the organizers re-enacted and photographed some actual accident situations which had occurred. The slide photographs presented leave an impression firmly etched in the mind of the viewer. They show how quickly and unexpectedly accidents can occur, and how rapidly and violently chemical reactions or fires can get out of control. It would be some comfort if these accidents entailed exotic chemicals, large amounts of solvents or reagents, or exceptional carelessness on the part of laboratory personnel. But they did not. Most were brought about by situations and practices that are commonly found in chemical laboratories throughout the world.

Presented here are a few ideas and impressions formed by the Editor while attending the course. Unlike many literature sources dealing with chemical safety, which are perfused with bland, non-committal and meaningless statements like "dispose of properly" or "take appropriate precautions", this article provides specific information and advice to be of maximum usefulness to the reader. Efforts have been made to ensure that this information is accurate at the time of writing. However, views on what constitutes safe laboratory practice may vary from one individual to another, or may change with time. The laboratory worker should seek information from as many sources as possible, and ultimately must rely on his own judgement for decisions relating to the safety of himself and others.

Nearly *all* chemicals found in a typical chemical laboratory are hazardous, emphasized Dr. Seymour Chissick during the opening session of the Hazardous Chemicals Course. By "hazard", he pointed out, we are referring to an intrinsic property of the substance—the ability to cause harm. A chemical might be flammable, explosive, corrosive, a powerful oxidizing agent, acutely toxic, or it might exert long-term effects that are not immediately apparent—possibly causing cancer or birth defects. We cannot change the hazards posed by the chemical; we can only reduce the risks associated with its storage, handling and disposal. To do that, we must no longer mislead ourselves into thinking of the chemicals in our laboratories as "potential hazards". They are hazards. They will injure or kill us if we let them, and we must take active steps to ensure that we have an acceptable level of protection.

To lower the risk of handling chemicals, Dr. Chissick urged, we should adopt a two-pronged strategy. First, the chemist must take all reasonable precautions to contain the chemical and protect himself from contact with it. Complete isolation of the chemical from the laboratory environment is usually impossible, so the chemist must evaluate the hazard posed by each chemical he uses, and make decisions about which precautions are reasonable and appropriate. Secondly, the chemist must develop a back-up system in the event that something goes wrong. A back-up system prevents a minor accident—a spill of flammable or corrosive liquid, escape of toxic gas, an imploding vacuum flask—from causing serious injury or death.

What became dramatically clear from numerous examples discussed during the course is that back-up systems must be well planned in advance if they are to be effective. All necessary equipment should be immediately at hand and ready for use, or already in place before the experiment is started. For example, should someone get corrosive material in his eye, permanent damage can result in as little as 5 seconds. The material must be flushed from the eye as soon as possible, and the eye washed with copious amounts of water for at least 15 minutes. There is little chance of preventing serious eye damage or blindness unless the laboratory is equipped with an eye-washing station (or at last a sink with a rubber hose). The equipment must be in operating condition, and laboratory workers must know how to use it. Urgency is especially important with alkali solutions. These penetrate rapidly into the tissues surrounding the eye, from which they are difficult to leach out. Alkalis, like all corrosive chemicals, may cause the eyelids to swell closed, and cause considerable pain. Dilute alkali solutions might not induce much pain, but they too can cause serious eye damage. In fact, the lack of pain might lead to eye-washing being stopped prematurely, allowing tissue damage to continue.

The back-up system may contain general safety equipment (fire extinguisher, breathing apparatus, etc), but also requires special equipment or procedures for specific hazards. Dr. Chissick pointed to the research group at his own institution (Kings College, London) who work with hydrofluoric acid, a particularly hazardous compound. Should a researcher be exposed to hydrofluoric acid, merely "seeking medical attention" (as advised by most safety manuals) would probably be of little help.

Most doctors are not familiar with hydrofluoric acid burns, would not recognize its symptoms, would waste valuable time identifying the recommended antidote, and might not have available the antidote necessary to prevent fluoride ion attack on the victim's tissues. So, each member of the research group is provided with a card with information and instructions for recognizing and treating fluoride poisoning. Each researcher carries an ampoule of the calcium gluconate antidote (which precipitates fluoride ions which have entered the tissues).

How can we identify the hazards associated with a particular chemical? The first source of information, the course lecturers emphasized, is the label on the bottle. This should state the major hazards posed by the compound, and provide advice on safe handling. The chemist should always read hazard warnings on labels. However, this information by itself might not be adequate for the chemist to decide how to handle the compound safely or to devise a back-up system. Vague phrases like "use with adequate ventilation" are common, but provide little meaningful guidance to the laboratory worker. Is room ventilation adequate, or does the laboratory worker need to handle the compound in a fume hood? Or, is it even necessary to handle the compound in a glove box? Similarly, the label might advise "Wear suitable gloves", but rarely will the label tell the reader what *types* of gloves are suitable. The label might also state that the compound is flammable, but usually does not convey how readily the compound is ignited. To decide how a compound should be handled, the chemist may need more information and guidance than he will find on the label. A compound poses a particularly serious fire/explosion hazard if it is sufficiently volatile to form a flammable vapour - air mixture at room temperature. It is not the liquid which burns, but its vapour. For the compound to ignite, its vapour concentration must exceed the minimum vapour - air concentration required to sustain combustion. Once the vapour is ignited, the flame may flash back along the stream of vapour. The liquid is heated by the flame and vaporizes at a much faster rate.

An indicator of how readily a compound ignites is provided by its "flash point", the temperature at which there is sufficient vapour concentration above the liquid to ignite. Any compound with a flash point below room temperature could ignite if it were spilled or placed in an open container near a suitable ignition source. Among common solvents with flash points below room temperature are acetaldehyde, acetone, acetonitrile, benzene, carbon disulfide, cyclohexane, diethyl ether, ethyl acetate and *n*-hexane. However, one should not interpret flash points too literally. The flash point of a compound can be considerably influenced by the presence of oxidizing gases (like chlorine) in the laboratory atmosphere, accumulation of volatile decomposition products in the solvent, or other factors.

Some solvents pose a particularly acute flammability hazard because they will ignite at relatively low temperatures *without a spark, flame or ignition source*. Carbon disulfide, with an autoignition temperature of 100°C, can ignite upon contact with a steam pipe or the surface of a hot plate. Diethyl ether and acetaldehyde also have relatively low autoignition temperatures. Furthermore, a compound

might still pose a flammability hazard even though its flash point is above room temperature. For example, aniline (with a flash point of 76°C) will ignite once it is heated, and will propagate a fire once it has started.

The danger of fire is probably the laboratory hazard least appreciated by chemists. The extent of the danger was driven home in case studies illustrated during the Hazardous Chemicals Safety Seminar. One would never intentionally drop a bottle of solvent on the floor to find out what would happen, but this was precisely what the course organizers did (photographing the results with a high-speed camera). The results were frightening. A bottle of aromatic solvent (like benzene or toluene) burned ferociously, giving off billows of thick black smoke. Even after the fire was put out by a dry powder fire extinguisher, vapours from the spilled solvent reignited on the hot glass fragments of the broken bottle. Had this occurred within an enclosed laboratory, the smoke would have completely filled the room within seconds. Anyone present would not be able to see, and would soon be overcome by the fumes unless he were wearing a self-contained breathing apparatus. If the heat liberated by the fire were sufficiently intense, it could shatter other glass bottles containing corrosive and flammable liquids.

Such events, it could be argued, are speculation. But what really *did* happen during one fatal laboratory accident was vividly re-created and photographed by the course organizers. They assembled a metal-frame storage rack and stocked it with the chemical reagents believed to have been present when the accident occurred. The storage rack was set up in a concrete bunker about the same size as the laboratory room in which the accident occurred.

The initial scene of the accident appeared no different than a chemical storage rack likely to be found in virtually any chemical laboratory. A few small reagent bottles had not been unpacked from their cardboard box, which had been placed unopened on the shelf of the storage rack. This is not uncommon to see in chemical laboratories, although it is considered inadvisable to keep combustible materials (like cardboard) with flammable chemicals. One cardboard box would seem a trivial infringement of safety procedures, but in this case, it was ultimately responsible for the death of a laboratory worker.

The accident was brought about when the worker tried to retrieve a bottle of solvent from the top shelf. He failed to get a secure grip on the bottle. It fell to the ground and shattered, spilling its contents around the base of the storage rack. The laboratory worker left the room to get a spill clean-up kit. In his absence, the solvent vapour ignited, engulfing the room in flames. During the short time he was away, the other bottles of chemicals remained intact, despite the intense heat of the flame. However, the burning cardboard box contributed an additional and localized source of heat. The adjacent metal column, which supported the rack, was weakened by the heat and finally buckled. It was at this point that the laboratory worker had re-entered the room, at the worst possible instant. As the rack collapsed, bottles of hot flammable solvents slid onto the floor and smashed, causing the entire room to explode into an inferno.

The striking thing about this incident is that each of the factors which contributed to the accident could be found in almost any chemical laboratory. The generally-accepted view among safety officers that cardboard boxes and other combustible materials be stored away from chemicals is commonly overlooked or ignored. Common sense dictates that chemicals should not be stored above eye level or in awkward positions. This too is frequently ignored.

The above incident demonstrates that any attempt to control a laboratory fire must be taken immediately—if it is to be taken at all. A fire extinguisher will likely be of value only if it is immediately at hand, which means that the fire hazard must be anticipated in advance. Finally, this accident demonstrates the risk of re-entering a room in which a fire has started. Possibly, the only circumstances which might justify this risk is to rescue a colleague.

The hazard of fire can be greatly reduced if laboratory workers dispose of unneeded solvents. Chemists should periodically examine the chemicals stored in their laboratory and ask “do I *really* need this compound?” Any chemical not being used should be returned to the storeroom or sent for disposal. Often, laboratory workers will find that some chemicals on their shelves have not been used for years. Other chemicals that had been shunted to the rear of a shelf may have remained there for years, probably having been forgotten when fresh supplies were ordered. Even for those chemicals being used, it is probably unnecessary to keep 3 bottles in the laboratory. Making a trip to the storeroom each time you need more reagent might be an inconvenience, but this modest effort is compensated by the smaller store of chemicals—and the smaller hazard—within the laboratory.

Compounds which have poor stability should be kept for a limited time, whether they are being used or not. Ethers are notorious for reacting with air to form explosive peroxides, but a substantial number of other compounds can also form dangerous peroxides (including tetrahydrofuran, decahydronaphthalene, acrylonitrile and styrene). Containers of such compounds should be date-stamped upon delivery to the storeroom, and date-stamped when opened by the chemist. Bottles that have been opened for more than 1 month, or unopened bottles more than a year old, should be routinely discarded. This system of date-stamping is only effective when chemicals are not frequently transferred from one container to another. When such transfers are made, all safety information on the label of the original container must be transferred to the new container.

Once the chemist has eliminated those chemicals he does not presently need, he should segregate those compounds that could react violently with one another. Never store oxidizing agents (like nitric acid, permanganate salts, or chromic acid) near flammable solvents. Should such chemicals inadvertently come into contact, they can ignite spontaneously. One storeroom fire, re-created by the course organizers, had apparently started when someone kicked over two bottles on the bottom shelf of a storage rack. One was an oxidizing agent; the other a flammable solvent. Another photograph showed the storeroom of a company which manufactures electronic components. Massive bottles of nitric acid



A carelessly-loaded chemical storage rack, similar to those which could be found in virtually any chemical laboratory, set the scene for a horrific laboratory fire. A laboratory worker had tried to reach a half-litre bottle of acetone on the top shelf, but fumbled and dropped the bottle. As shown in this recreation of the fatal accident, the bottle smashed, spilling its content of flammable liquid around the base of the storage rack (1).

The liquid ignited, giving rise to an intensely hot flame (2). The chemist returned to the laboratory as the initial fire was burning down, when it appeared that the main danger was over (3). Other bottles of solvent and reagents had surprisingly remained intact, but the metal supports of the storage rack had weakened where cardboard boxes had caught fire. The rack collapsed, allowing bottles of hot solvent to smash on the floor and engulf the room (in this recreation, a 5 × 7 metre concrete bunker) in an inferno of flame (4). *Photographs courtesy of J. T. Baker Chemical Company.*



completely filled the top shelf of a storage rack. On the bottom shelf were equally massive bottles of toluene. The company had set the scene for a disaster of major proportions.

To show how horrific a chemical fire can be, the course organizers included a movie film describing the Boiling Liquid Expanding Vapour Explosion, or BLEVE (pronounced "blehvee"). This type of explosion can occur whenever flammable liquefied gases are stored in large, sealed storage tanks. The phenomenon was first recognized and understood in the early 1970's, following several serious incidents in which railway tankcars filled with liquefied gases had derailed. In these incidents, gases leaking from damaged tankcars had caught fire. As the fire heated liquid in the intact sealed cars, the internal pressure increased, but escape of vapour through the emergency release valve initially prevented the pressure rising above a level which the tank could withstand. The liquid boiled inside, thereby cooling the bottom of the steel tank. However, there was no liquid at the top of the tank, which continued to be heated by the fire outside. In fact, as more and more liquid boiled away, the uncooled section at the top of the tank was increasing in size. The steel wall weakened as it became hotter until it finally ruptured. Superheated vapour burst into the air and instantly exploded.

An enormous amount of energy is released when about 100 000 litres of flammable liquefied gas explode. Burning vapours can give rise to a fireball more than 100 metres in diameter. The wreckage of the tankcar may be hurled as much as one kilometre, spewing hot burning liquid as it flies through the air. Flying debris can puncture nearby tankcars, leading to secondary explosions. The events leading up to one BLEVE were recorded by a television cameraman positioned several hundred metres from the burning tankcar. It was an eerie feeling for course participants to see the scene exactly as the cameraman had seen it instants before he was killed by the blast. Amazingly, a fireman perched on top of a ladder alongside the exploding tankcar survived (evidently due to his heavy protective clothing, breathing apparatus and good luck).

For solvents used in the laboratory, spillages can present immediate fire and toxicity hazards. The concentrations of vapour in the air can rise rapidly to levels that are flammable and/or highly toxic. The clean-up procedure used in many laboratories entails soaking up the spilled liquid in sand or other adsorbant solid. This procedure does prevent additional spread of the liquid, but does *not* eliminate the immediate fire or toxicity hazard. Solvent vapours permeate through the sand, where they can ignite or be inhaled. The escape of flammable vapours was convincingly demonstrated by the course instructors. They placed some adsorbant solid over a small amount of flammable solvent in a Petri dish, mixed thoroughly to ensure that the solvent had completely soaked into the material, and then ignited the apparently dry solid with a match.

A far safer and more effective way to clean-up solvent spills is with activated charcoal. Not only does it physically absorb the liquid solvent, but it chemically adsorbs solvent vapours. The effectiveness of activated charcoal in adsorbing solvent vapours was also demonstrated by the course instructors. They showed

that the solvent/activated charcoal mixture would not ignite. So effectively does activated charcoal bind flammable vapours that it can even be used to extinguish a fire (although it is not recommended for this purpose, since adsorbed compounds are released when the material is heated). Once the solvent has been adsorbed onto activated charcoal, the material can safely be scooped into a plastic bag for disposal. Based on the extraordinary properties of activated charcoal, which were most convincingly demonstrated, it appears to be an effective general-purpose clean-up agent for volatile liquids. Even if the spilled liquid is not flammable, the use of activated charcoal would greatly reduce exposure of the laboratory worker to toxic fumes. In the event of a large spill of a particularly toxic compound, vapour concentrations can soon reach levels that are dangerous or even lethal.

The main limitation in the use of activated charcoal as a clean-up agent is that large amounts are required to soak up and adsorb the liquid (as much as several kilograms for one litre of spilled solvent). The material should be kept in a sealed packet, since it gradually loses adsorption capacity when exposed to laboratory air. It is not suitable for cleaning up acid and alkali spills, which require neutralization, and special clean-up equipment is required for cyanide, hydrofluoric acid and mercury (although activated charcoal does adsorb mercury vapour). Activated charcoal should not be used to clean-up peroxides or oxidizing agents (such as perchlorate solution), since the adsorbed chemical could conceivably explode or ignite after the solvent has eventually evaporated. However, these limitations should not restrict the usefulness of activated charcoal. The protection it provides against fire and toxic vapours is impressive. It seems appropriate to suggest that every laboratory be provided with a package of activated charcoal, and personnel acquainted with its use.

The flammability hazard of a compound is relatively easy to assess. The flash point and autoignition temperature are well-defined physical properties that can be accurately measured. However, determining the toxicity hazard of a compound is quite another matter. The key question is: what level of exposure to the compound is safe? As early as the sixteenth century, the philosopher, Paracelsus concluded that "All substances are poisonous; there is none which is not. The right dose differentiates poison from remedy". To illustrate this point in a modern context, the course instructors cited chloroform as an example. A single dose of 50 ml will kill you, they pointed out, but this same amount is tolerated by the body (with no apparent ill effect) when ingested at low concentrations in cough medicines, toothpaste flavourings and de-cafeinated coffee.

It is believed that test animals and human beings can safely tolerate most chemicals when their concentration is below a threshold level. When this level is exceeded, normal detoxification mechanisms begin to be overloaded. The "safe level", if it exists, cannot be measured directly, but must usually be inferred from animal experiments and human experience. The concentration of vapour that is considered "safe" when inhaled by workers for 8 hours per day is termed the Threshold Limit Value, or TLV. The TLV is normally established at 1/1000 the concentra-

tion which is lethal to 10% of test animals. It is important to bear in mind that TLV's are *not* absolute. The fact that the vapour concentration in a laboratory is below the TLV does *not* guarantee that laboratory workers are not being harmed. On the other hand, if vapour concentrations exceed the TLV, this does not necessarily prove that the environment is harmful. Regulatory agencies may raise or lower TLV values, as indicated by the consequences of actual worker exposure.

The use of animal experiments is often the only practical basis for estimating a chemical's toxicity to man, and establishing TLV's. However, the susceptibility of different animal species to a particular compound may vary widely. It is known, for example, that the compound β -naphthylamine produces bladder cancer in man and dogs, but the compound exhibits very low toxicity (and no carcinogenic hazard) when tested on rats. The concentration of a compound which is lethal to a mouse might be ten times, or even one hundred times, higher than the level which is lethal to a man. Or, it could be less. Furthermore, even among members of one species, individuals may vary widely in susceptibility.

For some compounds, concentrations which are injurious to humans *have* been determined from industrial accidents or experience. The TLV for these compounds can then be set as 1/1000th the concentration which is known to be harmful. But is 1000 an adequate safety factor? It seems a reasonable number to use, but is entirely arbitrary. Very likely, the body could tolerate this level for long periods without ill effect, but this is not known with certainty. There has been considerable controversy about long-term effects of exposure to low concentrations of

chemicals, especially with regard to carcinogens. Some people believe that exposure to any amount of carcinogen, no matter how small, poses some risk.

The concentration of vapour is not the only factor which determines the effect of a compound on the laboratory worker. Depending on whether the individual is resting or working strenuously, the volume of air inhaled—and thus, the amount of the compound adsorbed into the body—can vary by as much as a factor of 30. Furthermore, in a real laboratory environment, the individual is often exposed to more than one compound. The effect of these compounds may be additive; one compound may greatly potentiate the effect of another; or one compound might oppose the effect of another. In very few cases are the existence of synergistic and antagonistic effects recognized and understood.

So what are TLV's good for? Despite their limitations, TLV's are the best available estimate of the maximum vapour concentration that can be safely tolerated during a working day (8 hours). They are useful reference levels, against which we can compare the vapour concentrations actually present in the laboratory. If the TLV is exceeded, we should assume the laboratory atmosphere to be hazardous. Individuals expected to work in this environment for any significant period of time should be provided with suitable respiratory protection. However, if the vapour concentration is below the TLV, this does not necessarily mean that long-term exposure to this environment will not have adverse effects. We should strive to reduce the vapour concentration as much *below* the TLV as is possible. For TLV's to be used in this way, the laboratory worker must be provided with equipment and guidance for measuring vapour

Safety testing of chemicals to be coordinated by International Programme on Chemical Safety

The lack of definitive information on the acute and long-term effects of chemical exposure is an international problem. By 1977, it had become clear that a collaborative approach was needed to avoid costly duplication of effort in assessing the hazards of chemicals, recommending guidelines on exposure limits, and developing meaningful test methods. The concept of an *International Programme on Chemical Safety* (IPCS) was then advocated by the World Health Organization. The programme has recently been established as a cooperative venture by the World Health Organization, International Labour Organization and United Nations Environment Programme, with its administrative centre at the WHO headquarters in Geneva, Switzerland.

The formation of the International Programme on Chemical Safety is expected to strengthen and consolidate the substantial activities relating to chemical safety already being undertaken by the three sponsoring organizations. Seventeen reports have already been published in the *Environmental Health Criteria* series. These review available toxicity data, testing methods and reported environmental concentrations for mercury, PCB's, lead, nitrogen oxides, nitrates and *N*-nitroso compounds, photochemical oxidants, sulfur oxides, DDT and its derivatives, carbon disulfide, mycotoxins, carbon monoxide, organotin compounds and manganese. Copies of

these reports are available from WHO offices.

A number of new programmes will also be initiated by the IPCS. One objective will be to develop guidelines on exposure limits for several classes of chemicals (including food additives, industrial chemicals, toxic natural products and pesticides, as well as chemicals used in household products, cosmetics and packaging materials). Many countries which lack facilities for undertaking their own safety testing could rely on the exposure limits recommended by an international panel of experts selected by IPCS. Very likely, developing countries would be willing to accept the guidelines for chemical exposure developed by IPCS, rather than adopt those established by any one national authority.

Another objective of IPCS will be to develop methods for assessing the effects of simultaneous exposure of individuals to several chemicals, and develop procedures for extrapolating data from animal experiments to human subjects. These methods must be usable by laboratories in all countries, emphasizes ICPS manager Prof. M. Mercier, and provide results that can be meaningfully compared and analyzed. IPCS also plans to coordinate laboratory testing and statistical studies of the incidence of disease, and promote research on dose-response relationships and on the mechanisms by which chemicals exert biological activity.

concentrations in the air (see feature article, "Detector tubes allow simple, low-cost analysis of gases and vapours", in previous issue of *Chemistry International*). He must ensure that his air samples are representative of the air actually inhaled by those working in the laboratory.

TLV's can also be interpreted as a relative index of toxicity, although this is not the purpose for which they are intended. The course lecturers felt that TLV's indicate the order-of-magnitude of the chemical's toxic hazard, on which chemists can base their decisions about the precautions required to handle that compound. A TLV of 1000, for example (for compounds like acetone or ethyl alcohol) indicates that the compound has low toxicity (and that other hazards, like fire, might be a more important consideration). Those compounds with a TLV of about 100 (like styrene, toluene and perchlorethylene) are rather more toxic, and require good room ventilation to be handled safely. Compounds with a TLV less than 10 (like bromine or phosgene), in the view of the course instructors, should be handled in a fume cupboard.

Of course, these are rough guidelines only, and the chemist must take into account the particular compound and circumstances under which he is working.

Some compounds, like phenol, are readily absorbed through the skin and require special handling precautions. Phenol is a particularly dangerous nerve poison. The main factor determining the danger of a phenol spill is believed to be the area of skin exposed to the chemical. A spill covering about 400 cm² of skin area (less than the surface area of one's forearm) is lethal. Should a laboratory worker get phenol on his skin, great care should be exercised to prevent the liquid coming into contact with unexposed areas. In one case in which a small spill was improperly washed with solvent, the "first aid" treatment spread the liquid over a large area of the individual's skin, ultimately resulting in his death. The liquid should be *carefully swabbed* off the skin with glycerine or polyethyleneglycol jelly.

The chemists might also need to take other factors into account in assessing the toxicity hazard of a compound. If a liquid has been heated, its vapour pressure will be much higher than at room temperature. Should the vapour escape, the concentration in the air can reach toxic levels—even if the compound has relatively low toxicity (that is, a high TLV). Another factor is how the TLV compares with the concentration that can be detected by smell. Ammonia has a TLV of 50 ppm, which is well above the concentration which can be detected by its sharp irritating odor. This compound should therefore be less dangerous to handle than phosgene, which attacks the lungs but does not induce local irritation at low concentrations. The 0.1 ppm TLV of phosgene is 1/20th the concentration which causes perceptible nose irritation.

For the same reason, even nitrogen gas—which many chemists would consider the most innocuous compound to be found in a chemical laboratory — can be deadly. Of course, under normal conditions, nitrogen poses no hazard. It is present everywhere in the atmosphere, and comprises 80% (800 000 ppm) of the air we breathe. No TLV values are listed for nitrogen. However, in a small room with poor ventilation, leaking nitrogen can displace enough oxygen

The Hazardous Chemical Safety Seminar is an intensive review of dangerous chemicals, including flammable liquids and solids, corrosive materials, toxic compounds, insidious hazards and compressed gases. It has been conducted for five years in North and South America (in English, French and Spanish). The course has recently been presented for the first time in the UK. The course organizers at J. T. Baker Chemical Company hope to receive funds from the World Health Organization and other sources to take the safety seminar to other countries where worker health and safety is emerging as a serious concern and priority. Information about the seminar can be obtained from William Norton Jr., Director of Safety Training, J. T. Baker Chemical Company, Phillipsburg, NJ 08865, USA.

from the air to asphyxiate an unsuspecting person. Nitrogen has no smell and—unlike carbon dioxide—does not cause gasping or discomfort when present in dangerously high concentrations. The individual is given little or no warning that the air is deficient in oxygen. In addition, nitrogen is normally stored in high-pressure tanks, which require special attention to their handling and storage. The compression energy of the high-pressure gas could be liberated very destructively if an unsupported nitrogen tank fell over and sheared its valve. This example demonstrates that one should not interpret TLV's too literally. They provide useful guidance, but the chemist must take into account the particular conditions in his laboratory.

Perhaps the greatest value of TLV's is for comparing the relative hazards when choosing among several solvents or reagents. In many cases, the course instructors emphasized, safer chemicals could be substituted in laboratory experiments. For example, there are extremely few cases where a chemist needs to use benzene, a compound which is known to be highly flammable, acutely toxic and almost certainly carcinogenic (having been implicated as a cause of leukemia). Virtually any reaction or chemical separation that can be carried out using benzene as a solvent can equally well be performed with toluene. Toluene poses less of a flammability hazard (its flash point of 7°C is considerably higher than that of benzene) and is considered far less toxic than benzene. Yet, benzene is still widely used in chemical laboratories.

Indeed, there is a real need to redesign many of the experiments being performed in chemical laboratories. Most of the experiments routinely carried out in analytical, research and teaching laboratories were designed before chemists were aware of the hazards of the chemicals involved. What is needed, course instructor Martin Pitt maintained, is a comprehensive effort to reformulate thousands of chemical tests and procedures now in use throughout the world. Individual chemists should spend time to see if their laboratory procedures can be modified to reduce the associated hazards. This would be time well spent, and publication of such improvements would be a very useful addition to the chemical literature. There is, of course, much that we still do not know about chemical toxicity, especially the long-term effects of chemicals, but we *do* know enough to make the laboratory a safer environment in which to work.

Television, audiotapes and chemistry kits are integrated with printed texts in innovative chemistry courses

A very large number of adults who are not catered for by the traditional university system in the UK can now take higher education courses through the Open University. These individuals cannot take time from work, or are not accessible to educational institutions, to obtain formal educational qualifications or professional training in the conventional way. Through the Open University, these students can study largely on their own and in their spare time.

Internationally, the Open University is known as a pioneer in innovative methods for teaching at a distance. Its experience provides a base for developing chemical education programmes for the future. It also serves as a model which institutions of higher education in other countries may wish to emulate.

The Open University does perform, on a modest scale, the traditional role of a university in undertaking research. However, its major contributions are its methods of teaching undergraduate-level courses and its production of high-quality teaching material. In this article I outline how this works in chemistry, and offer the prospect of collaboration to bring chemistry to a wider general audience.

by Dr. John D. Coyle
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All universities seek to increase knowledge and learning through research, and the Open University (OU) is no exception. It has well-equipped laboratories on the central campus, good library facilities and a number of postgraduate and postdoctoral research students (funded, in chemistry, either by the university or through awards of the Science and Engineering Research Council). In fact, postgraduate training is one of the few aspects of the OU that can be compared directly with conventional universities. The laboratory scene is much the same as that in other small chemistry departments, except there are no undergraduates. The growth of chemical research activity began slowly at the OU because of the university's commitment to develop a wide range of undergraduate courses over a relatively short period. However, the pace of research is now accelerating. Active research projects are underway, dealing with organometallic compounds, organic reactions mechanisms, synthesis, photochemistry, NMR, thermodynamics, theoretical chemistry and other areas.

The Open University offers general degrees (with or without honours), and operates a credit system. The unit of credit is large: six credits are required for a degree, or eight for an honours degree—and all

undergraduate courses are full or half credits.

A student studying a half-credit chemistry course might receive structured teaching texts and other printed material totalling about 750 pages (in A4 format). The course books are produced by a painstaking "course team" approach. The team collectively plans the content, orientation and organization of the course before an author begins to prepare the first draft of his contribution to the text. The author can expect detailed comments and criticisms by several colleagues on each of three successive drafts of the material. As a result of this thorough evaluation and refinement, the structured teaching texts are highly valued for use by chemical educators in other teaching situations. Some courses utilize reprints from the chemical literature or other "unstructured" material. For a new photochemistry course, we have specially commissioned a group of eminent photochemists to write a series of short articles, and this provides about one-half of the printed material for the course.

The student may also receive (through the post) audiocassettes and accompanying printed notes and diagrams. In addition, he watches a series of broadcast television programmes (or video-recordings) which have been made specially for the course by the BBC in partnership with the OU course team.

Printed notes are provided for use with the television programmes. The student's progress is evaluated on the basis of work that he submits. Some assignments are marked by computer, while more extensive written responses or essays are graded by course tutors. The student sits an end-of-year examination. On a number of occasions during the February-to-October academic year, each student has an opportunity to meet with a local tutor and with other students in face-to-face tutorials (hosting of these tutorials is made possible through the cooperation and support of other institutions of higher education, whose staff form a large part of the OU's body of part-time tutors). And finally, the student undertakes experimental work during the year.

Chemistry is an experimental science, and the OU recognizes that laboratory experience is an essential component of a science education. To meet this need, the OU Chemistry Department has developed three approaches to provide its students with experimental experience.

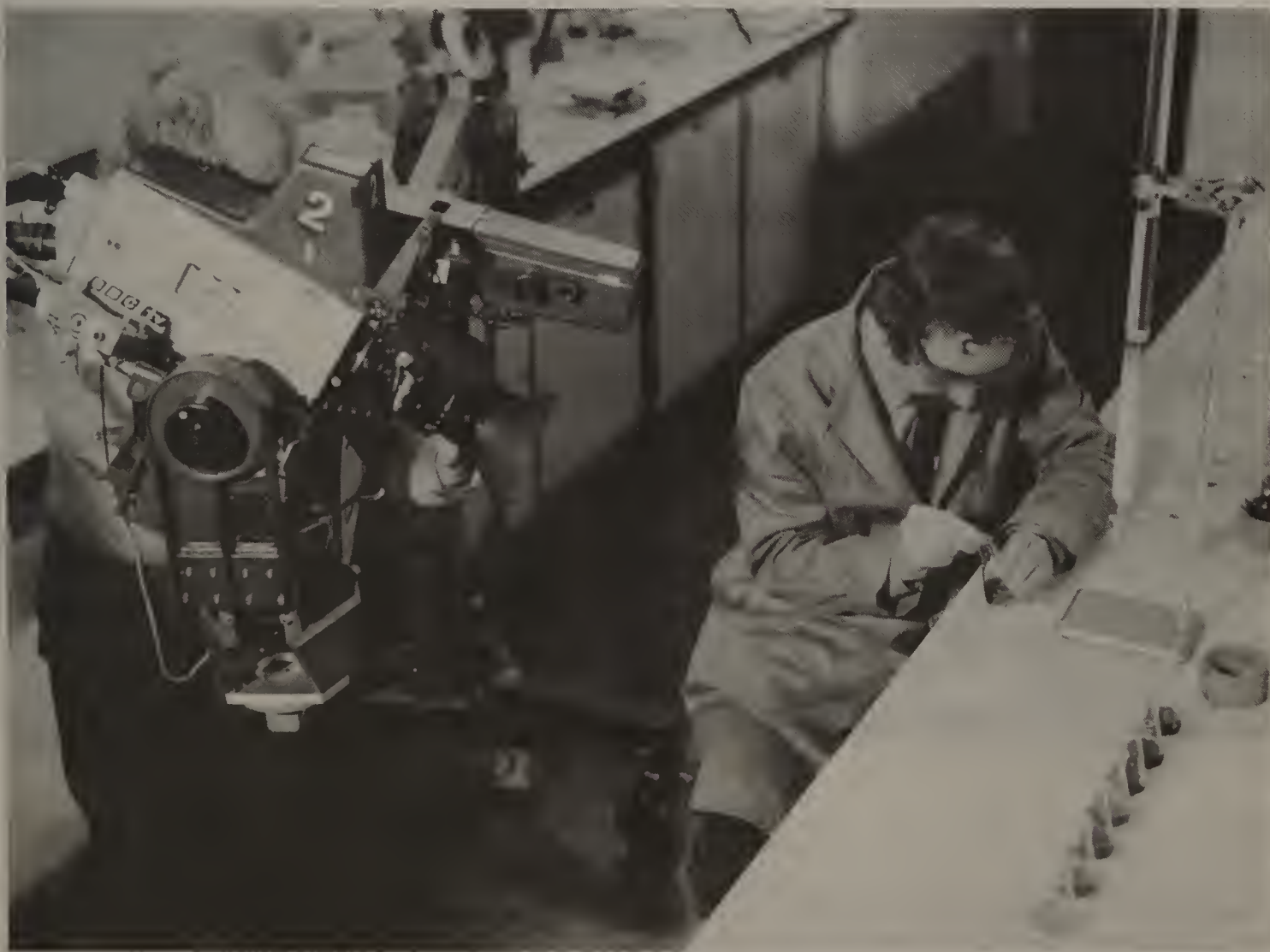
Television offers tremendous scope for imparting knowledge and experience of laboratory techniques. The student can see equipment in operation (such as photochemical smog chambers) that is inaccessible or too expensive for use in a normal university teaching laboratory. Or, by showing routine laboratory operations, television can supplement the student's own laboratory work. Television programmes produced

by the BBC/OU, and the accompanying printed notes, encourage the student to make his own observations, evaluate results, and comment on the design of the experiment.

Some chemistry courses have home experiment kits. These are packed in a large box and delivered to the student's home early in the course. They contain chemicals and equipment for a range of simple experiments to be performed during the year. Despite the limitations imposed by cost and safety considerations, the kits allow students to become more familiar with chemicals and apparatus, and to carry out chemical investigations.

Finally, within each chemistry course, a student attends a week-long intensive summer school using the facilities of a conventional university laboratory. The week's work includes approximately 38 hours of laboratory experiments, but a number of tutorials and other activities are provided as well. In order to make best use of limited time available, experiments to be performed by students are carefully evaluated. The experiments vary from two-hour exercises to week-long projects. We continue to be surprised that even students with no previous laboratory experience cope well, grow in confidence through the week, and are usually stimulated by the experience.

The content of most OU chemistry courses is fairly traditional. They include a general introduction to chemistry as part of a Science Foundation Course;



Techniques for carrying out routine laboratory operations, as well as experiments with unusual or very sophisticated equipment, can be demonstrated and explained through television. Television programmes produced by the Open University/BBC encourage the student to make his own observations and evaluate the results.

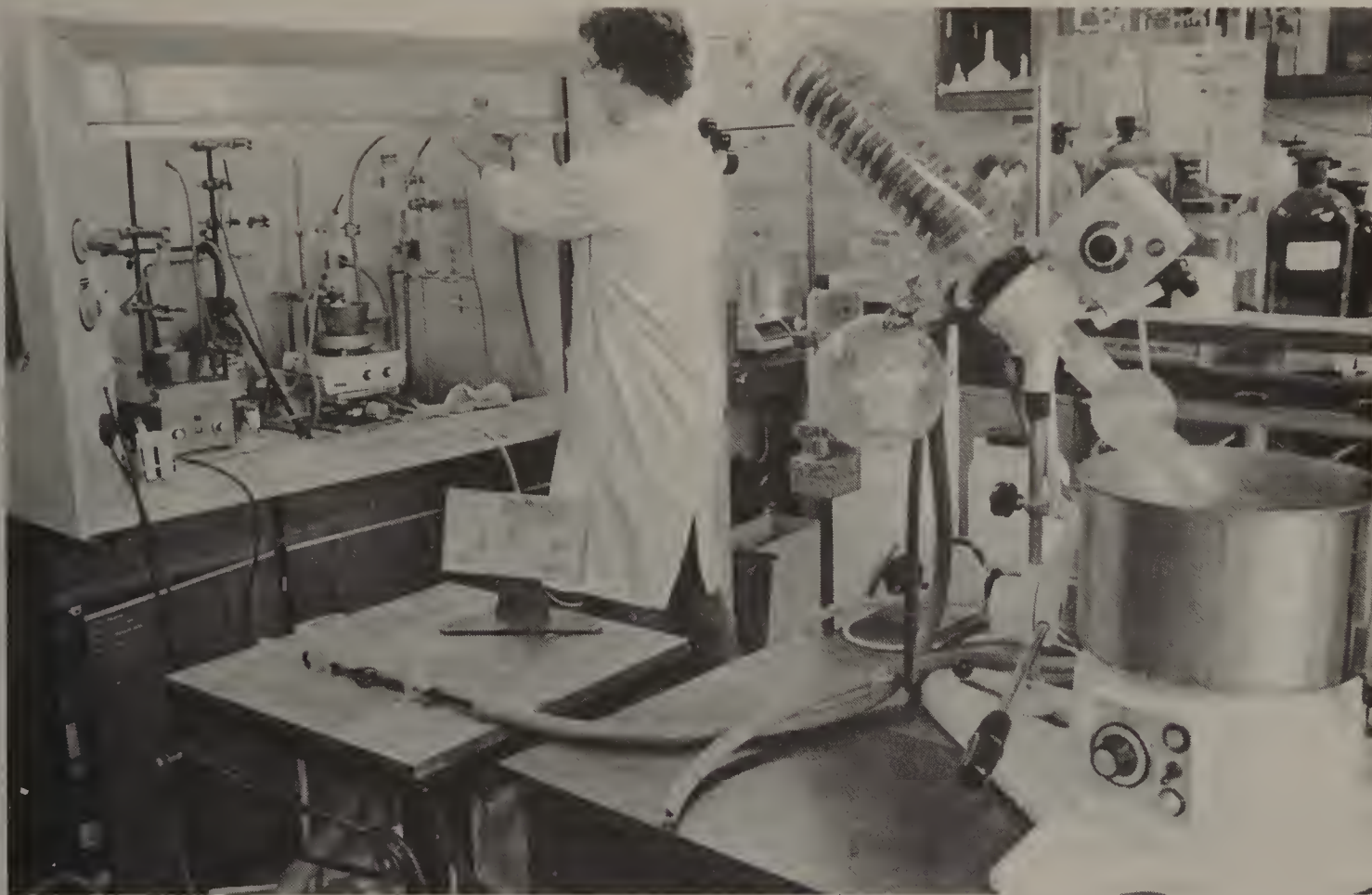


Students can carry out simple experiments using kits delivered to their homes early in the course. Each kit, like the one shown above, contains chemicals and equipment for a range of experiments to be performed during the year. Although safety and cost considerations restrict the type of experiments which the student can perform at home, the kits allow students to carry out simple chemical investigations. Experiments which require better facilities are performed during a week-long intensive summer school in a conventional university laboratory.

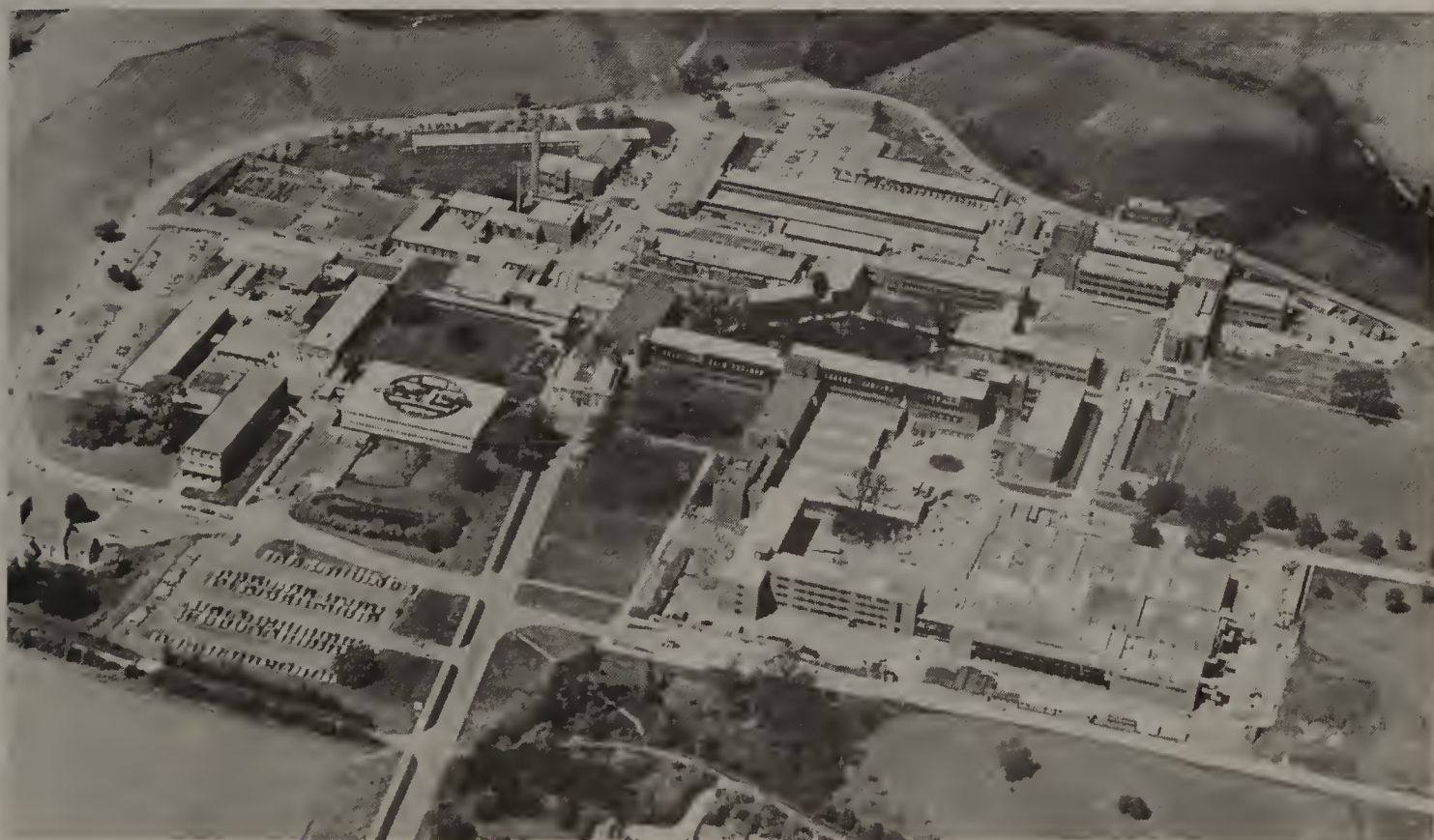


three "second-level" half-credit courses in inorganic, organic and physical chemistry; and a full-credit "third-level" course in advanced inorganic/organic chemistry. Much of this material could be found in conventional degree courses. However, an innovation introduced this year is a third-level half-credit course in photochemistry. This subject, which is not

extensively taught elsewhere, comprises a very large slice of the degree programme. The critical role of photochemical reactions in many phenomena is now widely recognized, and it is felt that the subject has such broad importance that it warrants emphasis in the OU chemistry curriculum. An understanding of photochemistry is essential for undertaking research



Research laboratories at the Open University look much the same as in other universities. In fact, postgraduate training is one of the few aspects of the Open University that can be compared with traditional university education. Research work, which is being undertaken on an expanding scale, is undertaken at the central campus of the Open University (shown below) in Milton Keynes, England.



on many topics of current interest: photosynthesis, solar energy conversion and storage, photo-imaging, photodegradation of polymers, and atmospheric chemistry. This course gives us the opportunity to examine these topics and their relationship to fundamental principles of photochemistry. By 1985, the

amount of third-level chemistry will be expanded to the equivalent of two credits. This will offer the OU student the opportunity to follow an Honours programme solely in chemistry after his work for the ordinary degree.

The Open University is heavily committed to

“continuing education”—that is, the provision of self-contained courses that are not intended as part of a degree programme. These courses may be designed for relatively small groups (to present recent developments to professional groups, for example) or may appeal to large segments of the general public (courses dealing with consumer affairs, for example). However, chemistry has not—so far—played a significant role in programmes aimed at the general public. Communicating chemistry to a general audience involves major conceptual and linguistic difficulties, but I hope that we will nonetheless make a major contribution in this area over the next few years. For continuing education courses we would want to work in collaboration with bodies responsive to specific professional or other interests. For example, teachers in primary and secondary science education might be one group for which new programmes could be developed. Such courses would be especially valuable for presenting new science teaching methods. We would like to develop a course for practising chemists, to update their knowledge of recent experimental results and theories in particular areas. It would also be very satisfying to produce a course which could describe to the general public how chemists manipulate materials, and convey the significance of chemistry in everyday life. Recognizing these areas of potential interest, and designing courses to meet these needs, present an exciting challenge.



Dr. John Coyle, the author, works in the Chemistry Department of the Open University.

Chemical nomenclature:

Where to find that name, symbol or unit that you are looking for

IUPAC recommendations for naming chemical compounds, and chemical terminology to be used, have been compiled into three major reference books^{*1, *2, *3}. Another volume^{*4}, prepared by the International Union of Biochemistry, provides a compilation of biochemical nomenclature. However, chemical nomenclature changes constantly, and it is necessary to publish revisions and additions separately (usually, in the IUPAC journal *Pure & Applied Chemistry*).

The following listing is intended to be a comprehensive guide to recent nomenclature recommendations. These are presented in two main sections. The first deals with nomenclature of chemical compounds: Analytical Reagents, Biochemical Compounds, Inorganic Substances, Organic Compounds, and Polymers. The second section contains chemical terminology, symbols, units and recommendations for presentation of results.

IUPAC has, in the past, followed a two-stage process for developing and disseminating nomenclature recommendations. Reports were initially published in *provisional* form. After comments had been received and considered, an amended *definitive* report was subsequently published.

A new procedure for publication of nomenclature recommendations, to be implemented this year, will no longer use the terms *provisional* and *definitive*. Nomenclature documents will simply be characterized by the year of adoption by IUPAC. In accord with this new policy, the provisional or definitive status of nomenclature recommendations are not indicated here. Each report listed, whether classified as *provisional* or *definitive*, is the most recently published on that subject.

REPRINTS & REPRODUCTION

Reprints of this nomenclature listing are available at no charge for single copies. Multiple copies can be purchased in lots of 10 at a cost of £2 (or US\$4) per 10 copies (including surface postage). Orders for multiple copies should be accompanied by a cheque payable to IUPAC, and addressed to the IUPAC Secretariat, 2 - 3 Pound Way, Cowley Centre, Oxford OX4 3YF, UK. Reproduction of the nomenclature listing (in whole or part) is permitted, provided that *Chemistry International* is acknowledged as its source.

NOMENCLATURE OF CHEMICAL COMPOUNDS

I. Analytical Reagents

Guide to Trivial Names, Trade Names and Synonyms for Substances used in Analytical Chemistry (*Pure & Appl. Chem.*, Vol. 50, No. 4, 1978, pp. 339 - 370).

II. Biochemical Compounds

AMINO ACIDS AND DERIVATIVES

Nomenclature of Amino Acids (Provisional Nomenclature Appendix No. 46, September 1975). Also published in *4.

Symbols for Amino Acid Derivatives and Peptides (*Pure & Appl. Chem.*, Vol. 40, No. 3, 1974, pp. 315 - 331). Also published in *4.

BIOCHEMICAL EQUILIBRIUM

Recommendations for Measurement and Presentation of Biochemical Equilibrium Data (Provisional Nomenclature Appendix No. 61, July 1977, *Info. Bull.*). Also published in *4.

CARBOHYDRATES & SUGARS

Symbols for Specifying the Conformation of Polysaccharide Chains (*Pure & Appl. Chem.*, Vol. 54, late 1982).

Abbreviated Terminology of Oligosaccharide Chains (*Pure & Appl. Chem.*, Vol. 54, No. 8, 1982 and *J. Biol. Chem.*, p. 257, 1982).

Polysaccharide Nomenclature (*Pure & Appl. Chem.*, Vol. 54, No. 8, 1982 and *J. Biol. Chem.*, p. 257, 1982).

Nomenclature of Unsaturated Monosaccharides (*Pure & Appl. Chem.*, Vol. 54, No. 1, 1982, pp. 207 - 210 and *Eur. J. Biochem.*, 119, 1 - 3, 1980).

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ADDITION COMPOUNDS

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ORGANOPHOSPHORUS COMPOUNDS

Section D of "Nomenclature of Organic Chemistry"*2.

ORGANOSILICON COMPOUNDS

Section D of "Nomenclature of Organic Chemistry"*2.

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Nomenclature, Symbols, Units and Their Usage in Spectrochemistry—Part V. Radiation Sources (*Pure & Appl. Chem.*, Vol. 53, No. 10, 1981, pp. 1913 - 1952).

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*1 **Nomenclature of Inorganic Chemistry** is a 110 page hardcover volume (published 1970) available from Pergamon Press. A 36 page softcover booklet "How to Name an Inorganic Substance" was later published (1977) as a companion guide.

*2 **Nomenclature of Organic Chemistry** is a 550 page volume published in 1979. It is available in hardcover and softcover editions from Pergamon Press, Oxford.

Section A: Hydrocarbons.

Section B: Fundamental heterocyclic systems

Section C: Characteristic groups containing carbon, hydrogen, oxygen, nitrogen, halogen, sulfur, selenium and tellurium.

Section D: Organic compounds containing elements that are not exclusively carbon, hydrogen, oxygen, nitrogen, halogen, sulfur, selenium and tellurium.

Section E: Stereochemistry.

Section F: General principles for naming natural products.

Section H: Isotopically modified compounds.

*3 **Compendium of Analytical Nomenclature** (published 1978) is available in hardcover and softcover editions. It includes terminology and nomenclature for precision balances, scales of working, contamination phenomena in precipitation from aqueous solution, automatic analysis, thermal analysis, mass spectroscopy, titrimetric analysis, standardization of pH, pH measurement in amphiprotic and mixed solutions, solution equilibria, liquid - liquid distribution, gas chromatography, chromatography ion exchange, atomic emission spectroscopy, data interpretation, flame spectroscopy, electroanalytical techniques, plotting electrochemical data. Published as a 222 page hardcover book available from Pergamon Press.

*4 **Biochemical Nomenclature and Related Documents** in a 220 page softcover manual published in 1978 for the Biochemical Society of IUB (available from the Biochemical Society Book Depot, P.O. Box 32, Commerce Way, Colchester, Essex CO2 8HP, England).

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Reporting Physisorption Data for Gas/Solid Systems with Special Reference to the Determination of Surface Area and Porosity (*Pure & Appl. Chem.*, Vol. 54, late 1982).

Reporting Experimental Pressure - Area Data with Film Balances (*Pure & Appl. Chem.*, Vol. 54, late 1982).

Recommendations for Nomenclature, Standard Procedures and Reporting of Experimental Data for Surface Analysis Techniques. Part IV of General Aspects of Trace Analytical Methods (*Pure & Appl. Chem.*, Vol. 51, No. 11, 1979, pp. 2243 - 2250).

Definitions, Terminology and Symbols in Colloid and Surface Chemistry—I. (*Pure & Appl. Chem.*, Vol. 31, No. 4, 1972, pp. 577 - 638). See also CATALYSIS.

SPECTROSCOPIC DATA INTERPRETATION

Nomenclature, Symbols, Units and Their Usage in Spectrochemical Analysis - Part II. Data Interpretation (*Pure & Appl. Chem.*, Vol. 45, No. 2, 1976, pp. 99 - 103). Also published in *3.

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Notation for States and Processes, Significance of the Word Standard in Chemical Thermodynamics, and Remarks on Commonly Tabulated Forms of Thermodynamic Functions (*Pure & Appl. Chem.*, Vol. 54, No. 6, 1982, pp. 1239 - 1250).

Calorimetric Measurements on Cellular Systems: Recommendations for Measurements and Presentation of Results (*Pure & Appl. Chem.*, Vol. 54, No. 3, 1982, pp. 671 - 679).

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General Aspects of Trace Analytical Methods. II. Standard Reference Materials for Trace Analysis (*Pure & Appl. Chem.*, Vol. 50, Nos 11 - 12, 1978, pp. 1531 - 1700). II. Contamination in Trace Analysis (*Pure & Appl. Chem.*, Vol. 50, Nos 11 - 12, 1978, p. 1519).

X-RAY SPECTROSCOPY

Nomenclature, Symbols, Units and Their Usage in Spectrochemical Analysis—Part IV. X-Ray Emission Spectroscopy (*Pure & Appl. Chem.*, Vol. 52, No. 11, 1980, pp. 2543 - 2552).

LETTERS

Continued from page 2

about 1.000 24. The second represents the difference between the traditional scale of atomic weights and the coherent SI unit, 1000. Errors of the second type are more often ludicrous than disastrous.

Let me concentrate on what to call the things. It is necessary to introduce more distinctive names if we are to progress any further than Humpty Dumpty and Alice in Wonderland: we should not stretch one name to cover both what John Dalton meant and what ICAW means. John Dalton's concept of atomic weight covered both 'elementary atoms' and 'compound atoms' (molecules) and can be equated with four modern kinds of quantity:

- (1) Mass of an entity (with SI units of kilograms).
- (2) Mass of a group of entities divided by the number of those entities. This, our Commission calls *entitic mass* (SI unit kg). We recommend this kind of quantity, for instance, in reporting the size of blood cells. Its value equals the mass of a single entity only if all entities are identical, as for a nuclide.

(3) Mass of a group of entities divided by the amount of substance of those entities, which the *IUPAC Manual of Symbols and Terminology for Physicochemical Quantities and Units* calls *molar mass* (SI unit kg/mol).

(4) Relative atomic (or molecular) mass, which simple logic shows to equal the numeric value of entitic mass in atomic mass units (u) and of molar mass in grams per mole. It could be called either *relative entitic mass* or *relative molar mass* (one or two syllables less than current usage).

The trouble with such relative quantities is the 'invisible' unit. For instance, specific weight is the numeric value of mass density expressed in grams per pre-1964 litre. The factor 1.000 028 for conversion to new litres is often forgotten and leads to systematic error in some published tables of viscosity.

The main concern of the Commission on Atomic Weights is to get the values right, and that takes time. The main concern of our Commission on Quantities and Units is more mundane: to get the names and symbols right. We need to express values in meaningful and easily calculable units and to provide unique names for the things we measure or calculate. We have to resign ourselves that discussions take time and that we will not get it right first time.

The issues raised in this letter are described more fully in a paper to be published in the next issue (1982, No.2) of the *IUPAC Division of Clinical*

J. Christopher Rigg
Member, IUPAC Commission on
Quantities and Units in
Clinical Chemistry

A chemical encyclopedia

When reading (and quoting) *Chemistry International* for my Dictionary/Encyclopedia, I keep saying to myself: One day they will perhaps also refer to Römpps Chemie-Lexikon as a source of the most reliable information in chemistry. Will they?

Yes. In fact, we have already briefly mentioned in a previous issue of Chemistry International (No. 2, 1982, p. 28) your kind offer to provide the IUPAC Secretariat with a complimentary set of Römpps Chemie-Lexikon. Your encyclopedia, for those not familiar with this unique reference work, describes chemical and physical properties, empirical formula and hazards for thousands of chemical reagents, drug compounds and engineering materials. Two volumes (each, about 800 pages) have already been published, and four more volumes will follow at approximately annual intervals. The encyclopedia is in German, although Volume 6 will contain an English/German and a French/German dictionary of terms.

RECENT REPORTS

Reporting physisorption data for gas - solid systems with special reference to the determination of surface area and porosity

The purpose of this Manual is two-fold: first to draw attention to the problems and ambiguities which have arisen in connection with the reporting of gas adsorption (physisorption) data and secondly to formulate tentative proposals for the standardization of procedures and terminology which, through further discussion, will lead to a generally accepted code of practice. It is not the purpose of this Manual to provide detailed operational instructions or to give a comprehensive account of the theoretical aspects of physisorption. Determination of the surface area of supported metals is of special importance in the context of heterogeneous catalysis, but this topic is not dealt with in this manual since chemisorption processes are necessarily involved.

The present proposals are based on, and are in general accordance with, the *Manual of Symbols and Terminology for Physicochemical Quantities and Units* and Parts I and II of Appendix II. Although it has been necessary to extend the terminology, the principles are essentially those developed in Part I.

This nomenclature report will be published in *Pure & Applied Chemistry* in late 1982.

Reporting experimental pressure - area data with film balances

The present guide provides the principles for reporting pressure - area data obtained with film balances for spread films. It contains six sections, a checklist covering the basic features discussed in the guide and a list of symbols.

In setting up the present guide, the main concern of Commission I.6 was to specify criteria for the reliability and reproducibility of reported results. Except for one modification, the nomenclature used is that recommended in an earlier document.

Although the guide deals only with the presentation of pressure - area data of spread film, it applies or may be extended to other properties of spread films.

Section I deals with the films and film balances in general. Two film properties: the total area and surface pressure are defined and several experimental conditions which may affect the results are mentioned.

The concept of the monolayer state for spread films and criteria for reliability of the data are introduced and discussed in Section II. Recommendations for the description of experimental conditions, of the apparatus and of the procedures involved are dealt with in Sections III and IV. In Section V, the presentation of the (numerical) values of the data and their units is considered.

Several applications of the film balance are briefly discussed in Section VI.

The checklist covers the basic features discussed in the present guide.

These nomenclature recommendations will be published in *Pure & Applied Chemistry* in late 1982 or early 1983.

Recommended approaches to the production and evaluation of data on pesticides

For the foreseeable future, agricultural pesticides will continue to be needed in the production, transportation and storage of food. The use of a pesticide can lead to residues remaining at harvest or other stages in the production of food, and the assessment of human hazards arising from the very small quantities of a pesticide in food has thus become an important part of the overall risk - benefit evaluation and is essential before a pesticide can be registered for use. One of the basic prerequisites of such assessments is the availability of reliable data on pesticide residues

in food, so that a realistic estimate can be made of the human exposure by this route. Authorities will only reach conclusions and make decisions if they are satisfied that the data are reliable, but variations in methods and techniques used in obtaining these data, including the selection, preparation and analysis of samples, have made it difficult to compare information from different sources and have contributed to differences in the regulations adopted in different countries.

The IUPAC Commission on Pesticide Chemistry has brought together a "manual" of internationally agreed procedures for obtaining reliable residues data. This includes guidelines for carrying out residue trials, sampling for pesticide residue analysis, guidelines for good analytical practice and recommendations for methods of analysis. This assembly of recommended procedures is supported by a commentary from the Commission on the interpretation of residues data with particular reference to maximum residue limits and the use of data for the prediction of consumer risks.

Guidance on the many aspects of producing and evaluating residue data will be of particular value to those countries still in the process of initiating procedures for the official control of pesticides.

This technical report has been published in *Pure & Applied Chemistry*, Vol. 54, No.7 (July 1982), pp. 1361-1450.

The nomenclature of hydrides of nitrogen and derived cations, anions and ligands

These rules apply mainly to nitrogen hydrides containing one or two nitrogen atoms. The hydrides are inorganic, but many of their derivatives are organic and the rules compromise between the relevant systems of nomenclature.

A systematic nomenclature based on the name "azane" for NH_3 and the atom name "nitrogen" is outlined, but the names recommended for present use are derived consistently from "ammonia" (NH_3), "hydrazine" (N_2H_4), "diazene" (N_2H_2) and "nitrogen" (N). The names "diimide" and "diimine" (N_2H_2) are not recommended. The cations derived from the nitrogen hydrides by the addition of one or two hydrogen ions are named using the "ium" ending, and the anions derived by the loss of one or more hydrogen ions by the use of the "ide" ending in the established manner. The anions resulting from the loss of all hydrogen as ions from the nitrogen hydrides are named from the atom, e.g. nitride (N^{3-}). The problem of naming ligands N_nH_m attached to transition metal ions where the actual valence bond structure of the ligand is indeterminate has been explored. The rules recommend that N_nH_m ligands should be named as neutral molecular species where possible, otherwise as anions, zwitterions or cationic ligands in that order

of priority, but not as radicals. A table of ligand names is appended.

These nomenclature recommendations will be published in *Pure & Applied Chemistry* in late 1982.

Determination of tin in foodstuffs and biological material

Regulatory and monitoring agencies usually require the determination of tin in canned foods at levels between 10 and 350 mg/kg. The following method is to be recommended as a simple and precise colorimetric procedure and is intended for the determination of tin in foodstuffs and biological substrates and is applicable for concentrations of tin down to two micrograms in the test portion.

The procedure includes a wet digestion using a mixture of nitric and sulphuric acids followed by treatment with perchloric acid and hydrogen peroxide. The acid residue is diluted with water to give an approximately 4.5 M concentration of acid. Potassium iodide is then added to the acid solution and tin (IV) iodide is selectively extracted into cyclohexane and then back extracted with sodium hydroxide into aqueous alkaline solution and subsequently acidified. The free iodine is removed by reduction with ascorbic acid, the chromophore catechol violet added and the solution buffered at pH 3.8 and left for 45 minutes at room temperature. Finally, the optical density of the resulting coloured complex with catechol violet is measured spectrophotometrically at 555 nm, and the amount of tin, calculated by reference to a calibration graph, is expressed in milligrammes per kilogram.

This technical report has been published in *Pure & Applied Chemistry*, Vol. 54, No. 9 (September 1982), pp. 1737 - 1742.

List of symbols with units recommended for use in biotechnology

A list of recommended symbols has been prepared by the Commission on Biotechnology of the International Union of Pure and Applied Chemistry. It is intended for use in conjunction with the various lists of symbols and units by the International Union of Pure and Applied Chemistry such as the 'Manual of Symbols and Terminology for Physicochemical Quantities and Units' (available from Pergamon Press Ltd.) and by the American Institute of Chemical Engineers, 'Letter Symbols for Chemical Engineering', published in *Chemical Engineering Progress*, 1978, pp. 73 - 80.

This nomenclature report has been published in *Pure & Applied Chemistry*, Vol. 54, No. 9 (September 1982), pp. 1743 - 1749.

CONFERENCES

IUPAC meetings are indicated in bold type

Additional information from address in parentheses

1983

OILS, FATS & WAXES

February 13 - 17. International Conference on Oils, Fats & Waxes. Auckland, New Zealand.
(Mr. S. G. Brooker, Department of Chemistry, University of Auckland, Private Bag, Auckland, New Zealand.)

IUPAC CONGRESS

June 4 - 12. 29th International Congress of Pure & Applied Chemistry. Cologne, Federal Republic of Germany.
(General Secretariat of the 29th IUPAC Congress, Dr. W. Fritsche, c/o Gesellschaft Deutscher Chemiker, P.O. Box 900440, D-6000 Frankfurt/M 90, Federal Republic of Germany.)

ZIRCONIA TECHNOLOGY

June 21 - 23. 2nd International Conference in the Science and Technology of Zirconia (ZIRCONIA-83). Stuttgart, Federal Republic of Germany.
(Nils Claussen, Max-Planck-Institut für Metallforschung, Institut für Werkstoffwissenschaften, Heisenberstraße 5, D-700 Stuttgart 80, Federal Republic of Germany.)

SPECTROSCOPY

June 26 - July 1. 23rd Colloquium Spectroscopicum Internationale. Amsterdam, The Netherlands.
(23rd CSI, c/o Organisatie Bureau Amsterdam BV, Europaplein, 1078 GZ Amsterdam, The Netherlands.)

PROPERTIES OF COPOLYMERS

July 11 - 14. 24th Prague Microsymposium: Copolymers, Structure and Solution Properties. Prague, Czechoslovakia.
(Dr. P. Kratochvil, c/o Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského n. 2, 162 06 Prague 616, Czechoslovakia.)

BORON CHEMISTRY

July 11 - 15. Imeboron V (Organic and Inorganic). Swansea, Wales, UK.
(Prof. A. Pelter, Department of Chemistry, University College of Swansea, Singleton Park, Swansea, West Glamorgan SA2 8PP, UK.)

ANALYTICAL CHEMISTRY

July 17 - 23. SAC 83 Conference and Exhibition. Organized by the Analytical Division of the Royal Society of Chemistry, University of Edinburgh, Edinburgh, UK.
(Dr. J. M. Ottaway, Department of Pure & Applied Chemistry, University of Strathclyde, Cathedral Street, Glasgow G1 1X1, UK.)

POLYMER STABILITY & PROCESSING

July 18 - 21. 25th Prague Microsymposium: Processing and Long-Term Stabilities of Hydrocarbon Polymers. Prague, Czechoslovakia.
(Dr. J. Pospisil, c/o Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského n. 2, 162 06 Prague 616, Czechoslovakia.)

TOXICOLOGY OF METALS

July 20 - 23. 2nd International Symposium on Clinical Chemistry and Chemical Toxicology of Metals. Montreal, Canada.
(Dr. J. Savory, University of Virginia Medical Center, Department of Pathology, Box 168, Clinical Laboratories, Charlottesville, VA 22908, USA.)

IUPAC GENERAL ASSEMBLY

August 18 - 26. 32nd IUPAC General Assembly. Lyngby/Copenhagen, Denmark.
(IUPAC Secretariat, 2 - 3 Pound Way, Cowley Centre, Oxford OX4 3YF, UK.)

CHEMICAL EDUCATION

August 21 - 26. 7th International Conference on Chemical Education "Chemistry Education and Society". Montpellier, France.
(Pr. M. Chastrette, Laboratoire de Chimie Organique Physique, Université Lyon I, 43, Bld du 11 Novembre 1918, 6922 - Villeurbanne, France.)

HETEROCYCLIC CHEMISTRY

August 21 - 26. 9th International Congress of Heterocyclic Chemistry. Tokyo, Japan.
(Yuichi Kanaoka, Faculty of Pharmaceutical Sciences, Hokkaido University Sapporo, 060 Japan.)

ORGANOMETALLIC CHEMISTRY

August 28 - September 1. 2nd IUPAC Symposium on Organometallic Chemistry directed toward Organic Synthesis. Dijon, France.
(Prof. J. Tirouflet, Université de Dijon, Boite Postale 138, 21004 Dijon Cedex, France.)

MICROCHEMICAL TECHNIQUES

August 28 - September 2. ISM '83, 9th International Symposium on Microchemical Techniques. Amsterdam, The Netherlands.
(Municipal Congress Bureau, Oudezijds Achterburgwal 199, 1012 DK Amsterdam, The Netherlands.)

CATIONIC POLYMERIZATION

August 30 - September 2. 6th International Symposium on Cationic Polymerization and Related Processes. Belgium.
(Prof. E. Goethals, Institute of Organic Chemistry, Riksuniversiteit-Gent, Krijgslaan 281 (S-4) B-9000 Ghent, Belgium.)

POLYMERIZATION OF HETEROCYCLES

September. International Symposium on Polymerization of Small Heterocycles and Aldehydes. Poland.
(Prof. Z. Jedlinski, Polish Academy of Sciences, Polymer Institute, POB 49, Curie-Sklodowskiej 34, PL-41 800 Zabrze, Poland.)

FOURIER TRANSFORM SPECTROSCOPY

September 5 - 9. International Conference on Fourier Transform Spectroscopy. Durham, UK.
(J.R. Birch, Division of Electrical Science, National Physical Laboratory, Teddington, Middlesex TW11 0LW, UK.)

MACROMOLECULES

September 5 - 9. 29th International Symposium on Macromolecules. Bucharest, Romania.

(Acad. Cristofor Simionescu, Institutul de Chimie Macromoleculara Petru Poni Aleea Grigore Ghica Voda Nr. 41A, Iasi, Romania.)

PHOSPHORUS CHEMISTRY

September 5 - 9. International Conference on Phosphorus Chemistry. Nice, France.

(Prof. J. G. Riess, Laboratoire de Chimie Minérale Moléculaire, Université de Nice, Parc Valrose, 06034 Nice, France.)

MOSSBAUER EFFECT

September 26 - 30. International Conference on Applications of the Mossbauer Effect. Alma Ata, USSR.

(Prof. V. I. Goldanskii, Institute of Chemical Physics, Academy of Sciences of the USSR, Kosygin Street 4, Moscow 117977 SZD 1, USSR.)

1984

CATALYSIS

July 2 - 6. 8th International Congress on Catalysis. Berlin, Federal Republic of Germany.

(DECHEMA, P.O. Box 970146, D-6000 Frankfurt am Main 97, Federal Republic of Germany.)

NATURAL PRODUCTS

July 9 - 14. 14th International Symposium on the Chemistry of Natural Products. Poznan, Poland.

(Prof. dr. Maciej Wiewiorowski, Institute of Bioorganic Chemistry, Polish Academy of Sciences, ul. Noskowskiego 12/14, 61-704 Poznan, Poland.)

ORGANIC CHEMISTRY

August. 7th IUPAC Conference on Physical Organic Chemistry. Auckland, New Zealand.

(Conference Secretary, Professor B. R. Davis, Chemistry Department, University of Auckland, Private Bag, Auckland, New Zealand.)

RAMAN SPECTROSCOPY

August 26 - September 1. 9th International Conference on Raman Spectroscopy. Japan.

(Prof. Mitsuo Tasumi, Department of Chemistry, Faculty of Science, The University of Tokyo, Bunkyo-ku, Tokyo 113, Japan.)

BIOTECHNOLOGY

November/December. 7th International Biotechnology Symposium. New Delhi, India.

(Prof. T. K. Ghose, Chairman, National Organization Committee & Head, Biochemical Engineering Research Centre, Indian Institute of Technology, Hauz Khas, New Delhi-110029, India.)

OFF THE PRESS

Recent IUPAC publications

Carotenoid Chemistry & Biochemistry

Carotenoids are the most widely distributed natural pigments, occurring in plants, animals and microorganisms. They are used extensively as food colourants, having the added advantage of provitamin A activity. They are now finding medical uses in the treatment of skin photosensitivity conditions, and are suggested as possible protective agents against some forms of cancer. The role of carotenoids in photosynthesis is also arousing much interest.

This volume, containing the main lectures at the 6th International Symposium on Carotenoids (held 26 - 31 July 1981 in Liverpool, UK), covers each of these aspects, as well as traditional areas of carotenoid chemistry and biosynthesis. The twenty-five papers have been prepared by specially invited experts, and comprise both up-to-the-minute review articles and reports on new work in important areas of carotenoid science and technology.

The 410-page book contains 295 illustrations and over 1500 literature references. It is available from Pergamon Press at a cost of US\$95 (or £47.50).

Stability constants of metal-ion complexes Part A: Inorganic Ligands

This book provides over 10,000 equilibrium constants which describe the stability of metal-ion complexes with inorganic ligands. Methods of

measurement, composition, temperature, medium, and thermodynamic properties are listed, as well as references to the original literature.

This 21st volume of the Chemical Data Series updates the 1964 edition of *Stability Constants of Metal-Ion Complexes* and its first supplement (published 1971). The enormous amount of data subsequently reported on metal-ion stability constants necessitated the division of data into two parts. The present volume covers inorganic ligands. The 324 page volume includes approximately 3000 literature references, and will be available from Pergamon Press for US\$85 (or £42.50).

Approaches to the characterization of aqueous effluents from the oil refining industry

In August 1981, the IUPAC Water Quality Commission and CONCAWE organized a workshop at the Catholic University of Louvain, Belgium, to consider approaches to the characterization of aqueous effluents from the oil refining industry.

The proceedings of this workshop have now been published as a 44-page report, which is available from John Lemlin—a member of the IUPAC Water Quality Commission—at Esso Research Centre, Abingdon, Oxford OX13 6AE. It includes a series of papers and a rapporteurs' report on plenary and mini-workshop discussions that took place over the three-day period.

Subjects discussed in the context of characterizing industrial effluents include chemical analysis at the micro-pollutant level, biodegradability, bioaccumulation, acute and chronic toxicity testing, ecological monitoring, and the assessment of mutagenic/carcinogenic potential. An introductory paper explains details of petroleum refinery operations and related water systems.

COMPUTERS & CHEMISTRY

— An International Journal —

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Computers & Chemistry is addressed to the chemist-programmer and to all those who are interested in the potentialities of computers in chemical research. It is concerned with both hardware and software, the emphasis being on how-to-do-it in both theory and practice.

TOPICS INCLUDE:

- * Theory of computing as applied to chemistry
- * Development of new algorithms
- * Evaluations of known algorithms
- * Methods of interfacing
- * Development of new hardware
- * Evaluation of hardware implementations
- * New applications of known algorithms
- * Methods for making a specific computation

Chemists need to know the best ways of gathering and processing their data. Papers addressed to these topics will be appropriate.

Computers & Chemistry accepts "Letters to the Editor". These must be brief and should contain information of special significance to chemists using computer techniques.

Some Previously Published Papers

C L DUMOULIN & G C LEVY, Development of an interactive spectral analysis system. Application to NMR spectroscopy.

Z ZLATEV, K SCHAUMBURG & J WASNIEWSKI, Implementation of an iterative refinement option in a code for large and sparse systems.

D HALL & P J LYONS, An appraisal of the applicability to molecular packing analysis of some global minimization techniques.

M RANDIC, G M BRISSEY, R B SPENCER & C L WILKINS, Use of self-avoiding paths for characterization of molecular graphs with multiple bonds.

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The International Union of Pure and Applied Chemistry (IUPAC), formed in 1919, is a voluntary, non-governmental, non-profit association of organizations, each of which represents the chemists of a member country.

Its objectives are:

to promote continuing co-operation among the chemists of the member countries;

to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;

to co-operate with other international organizations which deal with topics of a chemical nature;

to contribute to the advancement of pure and applied chemistry in all its aspects.

The membership of IUPAC presently comprises 43 countries, each represented by a national organization, such as an academy of science or research council.

NATIONAL MEMBER ORGANIZATIONS

Academy of Scientific Research and Technology (**Arab Republic of Egypt**)

Asociación Química Argentina (**Argentina**)

Australian Academy of Science (**Australia**)

Verein Österreichischer Chemiker (**Austria**)

Comité National Belge de Chimie (**Belgium**)

Associação Brasileira de Química (**Brazil**)

Bulgarian Academy of Sciences (**Bulgaria**)

National Research Council of Canada (**Canada**)

Chinese Chemical Society, and Chemical Society located in Taipei, China (**China**)

Ministerio de Minas y Petróleos (**Colombia**)

Academia de Ciencias de la República de Cuba (**Cuba**)

Czechoslovak National Committee of Chemistry (**Czechoslovakia**)

Det Kongelige Danske Videnskabernes Selskab (**Denmark**)

Suomen Kemian Seura (**Finland**)

Comité National Français de la Chimie (**France**)

Deutscher Zentrallausschuss für Chemie (**Federal Republic of Germany**)

Akademie der Wissenschaften der DDR (**German Democratic Republic**)

Association of Greek Chemists (**Greece**)

Hungarian Academy of Sciences (**Hungary**)

Indian National Science Academy (**India**)

Iraqi Chemical Society (**Iraq**)

Royal Irish Academy (**Ireland**)

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Malaysian Institute of Chemistry (**Malaysia**)

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Royal Society of New Zealand (**New Zealand**)

Norsk Kjemisk Selskap (**Norway**)

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Korean Chemical Society (**Republic of Korea**)

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Supreme Council of Sciences (**Syrian Arab Republic**)

Türkiye Kimya Derneği (**Turkey**)

Academy of Sciences of USSR (**USSR**)

Royal Society (**United Kingdom**)

National Research Council, National Academy of Sciences (**USA**)

Instituto Venezolano de Investigaciones Científicas (**Venezuela**)

Unija Hemijskih Društava Jugoslavije (**Yugoslavia**)

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Chemistry International

The news magazine of the International Union
of Pure and Applied Chemistry (IUPAC)



Surface chemistry in Australia:
on top, down under



1982, No.6(December)



Pergamon Press

CHEMISTRY INTERNATIONAL

The news magazine of the International Union
of Pure and Applied Chemistry (IUPAC)

EDITOR: Dr. Martin Gellender

SECRETARIAL ASSISTANT: Tricia Traynor

PRODUCTION ASSISTANT: Julie Sullivan

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PROPOSALS FOR ARTICLES

Those wishing to write articles or propose topics for coverage in Chemistry International should write a brief letter to the Editor, explaining why the subject might be of wide interest or significance. Correspondence to the Editor should be sent to the IUPAC Secretariat, 2-3 Pound Way, Cowley Centre, Oxford OX4 3YF, UK.

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Editorial Policy:

Chemistry International

Chemistry International (CI) was launched during 1979 as the news magazine of the International Union of Pure and Applied Chemistry for a trial period of three full years. At the end of that period, its function has been reviewed by the Officers of the Union and discussed by the Bureau and by the Publications Committee. As the readers will see from the editorial in this issue, we have also unfortunately at this stage lost the services of our Editor, Dr. Martin Gellender; indeed he has had to complete the present issue from his new home in Australia. We extend our grateful thanks to him for his services to CI over the past four years and wish him and his family the best of health and fortune in their new venture. It is the end of an era during which CI has won a reputation as an attractively set out and interesting *general* news magazine.

Readers of CI will wish to know what decisions have been reached about the future of the magazine and how it may change as a result of this review, the departure of the Editor, and the possibility of impending changes in the Union itself if, in August 1983, the Council approves a scheme of Affiliate Membership.

In reaching our decisions about the future of CI we have borne in mind its primary purpose of acting as the news magazine of the Union and the readership to which it is addressed. At present CI is issued to all the chemists who are members of the Commissions and Committees of the Union, to the National Adhering Organizations who are the members of IUPAC and to the Associated Organizations and Company Associates. In addition, there are approximately 1000 subscriptions from libraries and private individuals. If the Affiliate Scheme comes into being in 1984 or 1985, CI will also be sent to all those individual chemists who become Affiliates of IUPAC. Since the numbers of the latter could have a substantial impact on circulation we are, or rather may be, at a cross-roads.

However that may be, it is our intention to adhere to the main purpose of CI, i.e. to keep it in being as the news magazine of the Union. The predecessor of CI was the *Information Bulletin* (IB). The Bulletin carried the minutes of most of the main Committees and all the Commissions of the Union in considerable detail and gave reports of IUPAC-sponsored symposia and fairly detailed accounts of future meetings of both IUPAC and its Associated Organizations, etc. It served to keep all who were engaged within the Union fully informed about the work of their own Divisions and Commissions and also that of all other Union bodies. It was judged by many within IUPAC to be a most worthwhile publication, but was thought by others to be rather too factual and 'heavy'. The Bulletin certainly lived up to its name of being a vehicle for information on IUPAC activities, but to many IUPAC chemists and certainly to others outside IUPAC it was rather formidable to penetrate. It lacked *interpretative* articles that would have allowed chemists to appreciate what IUPAC was doing as a whole, what its objectives were, what 'live' issues existed or were about to emerge, etc. In other words, it lacked 'news' and 'feature' articles and hardly ever carried photographs or illustrations. CI sought to redress this balance and no one who compares it with IB can fail to notice the relatively attractive format and readability of CI.

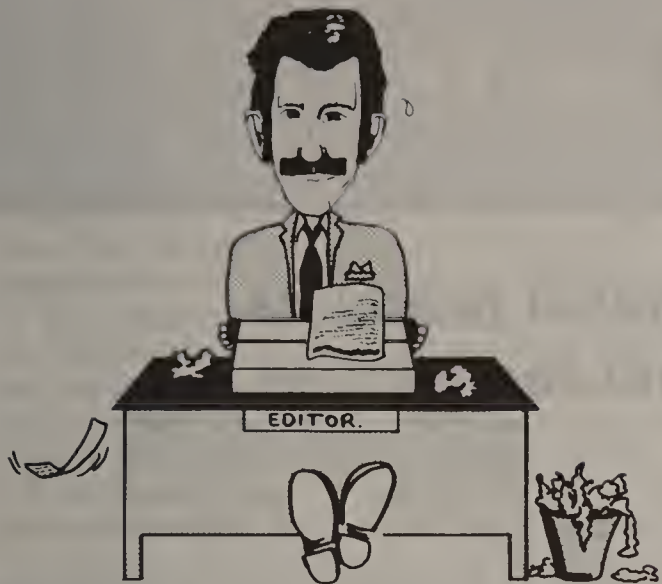
However, our view is that CI has tended to go to the other extreme and though extremely readable and attractive has, during this experimental period, carried relatively too little IUPAC material. In hindsight, we can see that Dr. Gellender took on a task that was too demanding for any one individual. No single person can comprehend the full range of IUPAC's activities and write about them interpretatively without having extensive help from the chemists of the Union *on an organized basis* to provide the back-up for information gathering. It is our intention, therefore, that Dr. Gellender's successor will be provided with the facility of an Editorial Advisory Board appointed from within the IUPAC bodies. It will function in an auxiliary newsgathering capacity to the Editor, alerting him, or her, to newsworthy items of interest to chemists inside and outside IUPAC which have

arisen or are about to arise within our Divisions, Commissions, and other bodies. The Board will also be available to check over interpretative material from the Editor upon request and to meet with him/her at General Assemblies to keep the policy and contents under review, to discuss future articles, etc. CI will, of course, continue to publish synopses of recommendations on nomenclature and symbols and other reports issued by the Union and so forth.

Thus, we hope by a shift of emphasis in future to retain the attractive journalistic style and nature of CI as far as possible, but to concentrate almost exclusively on IUPAC news and feature articles and to set in hand an editorial mechanism or infrastructure within IUPAC to allow this to be done successfully within the resources at our disposal. We are, however, at a cross-roads with respect to CI in that these resources and, to a limited extent, the purposes of CI may be influenced from 1985 onwards by the emergence of an Affiliate Membership Scheme within IUPAC.

For this reason we have decided to appoint a temporary part-time Editor at least for 1983 and to produce CI as before with six issues per year and approximately the same number of pages. Initially the first issues may have a rather high factual content, but we will progressively increase the interpretative material. Very fortunately, we have been able to secure the part-time services for this purpose of Mr. R. W. Fennell, who was formerly a Commission Member and subsequently the Secretary of the Analytical Chemistry Division of IUPAC and is particularly well versed in the structure and workings of the Union. Mr. Fennell will be in charge of CI with effect from January 1983 and we are most grateful to him for helping us out in this interim period. We hope that all IUPAC chemists will find the re-orientated CI worthwhile as their news magazine and that we will continue to have the support and interest of other subscribers whilst we work towards the style and coverage which we plan for the CI of the future.

Honorary Officers of IUPAC
and
Chairman of Publications Committee



THE EDITOR'S DESK

Opinions expressed here are those of the author, and do not necessarily reflect the views or policy of IUPAC.

Turning point

To me, this issue of *Chemistry International* has special significance. It represents a turning point in my life. It marks the completion of my role as Editor of *Chemistry International*, the end of a four-year stay in the UK, and the beginning of a new life in Australia.

Starting the first international chemistry news magazine was the most demanding assignment that I had ever undertaken. It was not easy trying to keep track of important scientific developments, select those of fundamental significance, extract the underlying concepts, and discuss complex technical details in a way that any chemist could readily understand. Many people had thought that it was impossible to report such developments simply and clearly, while maintaining a high standard of accuracy and objectivity. I always believed that simple writing was entirely compatible with accurate reporting, and I tried to prove this in the pages of *Chemistry International*.

The editorial content of *Chemistry International* has reflected my own outlook on chemistry, and my interpretation of events. Many of the articles were researched and written by myself; the rest were prepared and edited to my specifications. I composed many of the diagrams, took some of the photographs, and assembled the layout. I worried when there were production problems, but enjoyed a rare sense of achievement and satisfaction when each issue appeared in print.

While *Chemistry International* has been "my baby", and entirely under my editorial control, it has certainly not been a one-man effort. Many individuals offered their time and expertise, provided photographs and ideas, and contributed manuscripts. My secretarial assistant, Tricia Traynor, relieved me of much typing of correspondence, alterations to manuscripts, and the bother of having to read my own handwriting. I would also like to give special thanks to Julie Sullivan and the production crew at Pergamon Press, who have undertaken the additional task of proof-reading and layout preparation for this and the previous issue. I am very grateful to the Chemistry Department at the University of Queensland, which has very kindly provided me with office space and access to library facilities to assist in the preparation of this issue. And, most of all, I would like to thank my wife and family for providing the encouragement and support, without which I could never have undertaken this venture.

Synthesis of complex chemical products is feasible with new enzyme techniques

Enzymes will perform a much broader role in the synthesis of complex chemical products. At least, that was the impression consistently conveyed by speakers at a recent Discussion Meeting on Industrial and Diagnostic Enzymes (held at the Royal Society in London on 16 and 17 June 1982). Professor B. S. Hartley, one of the meeting organizers, prefaced the meeting by noting that perhaps only 1% of the microorganism species which exist in nature have actually been identified; the remaining 99% representing an enormous biotechnology gene pool. He speculated that the number of enzymes which could ultimately be applied in research and commercial applications far exceeds the number which are now known to exist.

Of the 2200-or-so enzymes that have been isolated, only a few dozen have the stability, activity and other properties necessary for successful commercial application on a wide scale. In fact, the most important breakthroughs in biotechnology will probably not involve the discovery of new enzymes, but will entail improved technology that will allow presently-available enzymes to be applied more efficiently. Enormous gains in achieving long enzyme lifetimes and greatly enhanced cost-effectiveness will likely be achieved by developing new techniques for binding enzymes to solid surfaces.

Most of the enzymes that have been successfully utilized in commercial applications, noted Dr. C. R. Lowe (of the Biochemistry Department at the University of Southampton, UK), are hydrolytic enzymes that are exuded *outside* the cell in which they are synthesized. Since they normally function outside the cell, in an environment that is not rigidly controlled, hydrolase enzymes are generally quite robust. Most are small protein molecules (with molecular weights of about 25 000), and are relatively stable. Their lifetimes usually increase when they are adsorbed, bound or somehow "immobilized" onto a surface (where they are less vulnerable to attack and degradation by other bacterial cells). These enzymes catalyze hydrolysis reactions, whose free energy change favours the spontaneous formation of products. In other words, hydrolase enzymes act solely as catalysts — lowering the activation energy for a reaction so that it can spon-

taneously "run downhill". This is not the case for another common type of enzyme, oxido-reductases. They serve not only as catalysts, but also couple with an energy source (a "coenzyme" molecule like ATP or NADH) to drive a reaction which would not — and could not — otherwise occur. Oxido-reductase enzymes are generally large proteins, and their activity is often reduced by a factor of 10 or 100 when they are immobilized.

Why is it so important to immobilize enzymes? Most conventional fermentation processes do *not* require immobilized enzymes: they utilize living bacterial cells to generate enzymes in the reactant solution, as Dr. C. Bucke (of Tate & Lyle's Research Laboratory in Reading, UK) pointed out. But the production of materials (such as beer or cheese) by conventional fermentation is a fairly messy process from a chemist's point-of-view, and is quite different than the synthesis of a pure chemical product. The product solution is contaminated by bacterial cells and fermentation byproducts; the product stream is dilute; there is considerable batch-to-batch variation in the growth rate of bacteria and the product quality; and conventional fermentation requires very large and expensive fermenters. Conventional fermentation is fine for producing biomass, Dr. Bucke argued, but is not well suited for producing pharmaceuticals or other speciality chemicals. These applications require the use of pure enzymes, and these are too expensive to be used once and then thrown away. The enzymes must be bound to the surface of a solid so they can be retained in the fermentation reactor, acting continuously on reactant solution flowing through the reactor vessel.

Until now, immobilization techniques have essentially been limited to extracellular enzymes (those which normally act outside the cell). These are relatively easy to isolate and purify, are usually stable during isolation and use, and catalyze a single-step reaction. However, new techniques are making it feasible to immobilize other types of enzymes, as became clear from Dr. Lowe's lecture. His research group is studying the immobilization of oxido-reductases, enzymes which normally function *inside* a living cell. To bring about an oxidation or reduction reaction, these enzymes must come into contact with coenzymes molecules. Bonding the enzyme

to a solid support so that it can still interact with a coenzyme molecule poses a difficult challenge. The coenzyme too must be bound to the surface, which is achieved by using a spacer molecule. The activity of the enzyme/coenzyme system is determined not only by the site on the coenzyme molecule where it is bound to the spacer molecule, but also depends on the nature of the spacer molecule and the support surface. The chemical conditions used to immobilize the enzyme determine the microenvironment at the solid surface, and this in turn determines the activity and stability of the enzyme system.

Coenzymes are relatively small, low-molecular-weight molecules, but they are too expensive to be used only once. They must be regenerated if immobilization of the enzyme is to be practical and economical. To regenerate an energy-rich coenzyme like ATP or NADH, we need another enzyme — and an energy-producing reaction. For example, we can regenerate NADH by oxidizing formate ions with an immobilized formate dehydrogenase enzyme. The reaction product, carbon dioxide, bubbles out of the solution and therefore does not contaminate the product stream. Then, the NADH can drive the desired reduction reaction (say, the reduction of a carbon-carbon double bond adjacent to a carboxylic acid group, using an enoate reductase enzyme). We can thus alternate the reactant solutions percolating through the immobilized enzyme: first using the substrate solution to be reduced, and then formate solution (to “recharge” the coenzyme). Enzymes for both reactions must be immobilized on the same support, and both enzymes must

be able to interact with the coenzyme.

Rather than isolating, purifying and immobilizing a particular enzyme, it is sometimes simpler to immobilize entire cells. In fact, immobilized cells are now used commercially for the isomerization of glucose, production of malic acid from fumaric acid, and conversion of sterols. Immobilized cells are most suitable, Dr. Bucke pointed out, for multi-step processes which use unstable enzymes and which require a clean product stream. In fact, many bacterial cells normally live in the natural environment by adhering to the surface of soil grains or other particles. Various laboratory processes can be used for flocculating, polymerizing, adsorbing or entrapping cells within a solid surface. Dr. Bucke felt that entrapment in a collagen or polysaccharide gel was probably the best general method. He found that, by using polymers extracted from natural sources (like K-carrageenan or calcium alginate), it is possible to prepare gels very simply in which entrapped cells have surprising longevity. The immobilized cells can sometimes tolerate higher substrate concentrations and have longer lifetimes than cells in free solution. Dr. Bucke anticipated that researchers will soon develop the capability to immobilize several organisms on one support medium, to immobilize intact cells *and* pure enzymes on the same support, and to use immobilized cells to produce extracellular enzymes. The immobilization of pure enzymes, and of entire cells, might thus prove to be complementary techniques, both benefiting from fundamental advances in enzyme chemistry.

Recent evidence points to a strong link between inorganic chemistry and life

Biochemistry and inorganic chemistry are frequently regarded as being two entirely independent scientific disciplines. Developments in one field are usually regarded as having little or no relevance to research work in the other. However, the isolation of these two fields of chemistry, reflecting the traditional division of chemistry into organic and inorganic chemistry, might finally be breaking down. An increasing amount of evidence is pointing to a wide range of important functions performed by inorganic salts and compounds in living cells. Many chemists now recognize that there is substantial overlap between biochemistry and inorganic chemistry, and there is growing acceptance of “inorganic biochemistry” as an important interdisciplinary area. Pharmacologists, for example, are exploiting the potent and highly specific biological activity of some

organometallic complexes in developing new drugs for the treatment of cancer, microbial infections and arthritis.

It has been known for a long time that living cells can accumulate, chemically modify and utilize metal ions to synthesize enzymes and electron-transport intermediates. Crystalline minerals can be deposited or assimilated by specialized cells, forming bone and shell. Bone is perhaps the best example of a living tissue in which cell protoplasm and inorganic minerals are fully integrated in one structural matrix. The cells in this rigid material can deposit minerals in one part of the bone and dissolve them elsewhere, adapting its structure and shape to withstand applied mechanical stress.

The relationship between inorganic minerals and living organisms may be much more fundamental than anyone had realized. In his

paper "Replication and Evolution in Inorganic Systems",* Prof. Dr. Armin Weiss proposes that microscopic crystals of clay minerals could have played a fundamental role in the growth and reproduction of the first "living" organisms to appear on the Earth's surface some 3.5 to 4.5 billion years ago. Prof. Weiss explains that crystalline silicate particles have the capability—under certain conditions—to catalyze specific chemical reactions, and to reproduce their own structure. It is therefore reasonable to speculate that the first cells could have utilized mineral particles to synthesize compounds needed for cell growth and to encode the genetic make-up of the cell, in much the same way as these functions are presently performed by the nucleic acids DNA and RNA in all cells.

Clay minerals vary widely in composition, but all consist of parallel layers of (negatively-charged) crystalline platelets held together by electrostatic attraction to positive ions within the interlayer spaces. Normally, each platelet of a silicate crystal has a distinctive structure, with some Si^{4+} ions replaced by Al^{3+} ions (and Mg^{2+} substituting for some Al^{3+} ions) at specific sites in the crystalline layer. The catalytic activity and chemical properties of a silicate crystal depends upon the number of substituted ions and their particular sites within the platelet layers.

When a crystal of the mineral montmorillonite is placed in a medium containing $\text{Si}(\text{OH})_4$, Al^{3+} , Mg^{2+} , Na^+ and K^+ at appropriate concentrations, new platelets grow in the space between layers of the crystal. Each new platelet acquires the same structure, with the same distribution of substituted ions, as the adjacent crystal layers. When the growth medium is diluted, as might occur during a period of thaw or heavy rains, the crystal separates into individual platelets—each with an identical structure.

This mechanism whereby platelets of identical structure are produced is strikingly similar to the replication of the genetic code on a strand of DNA. Reproduction of the crystal structure, like the replication of DNA, is not perfect, and some offspring would have had a slightly different composition and genetic make-up from the parent organism. Certain crystalline structures would have been more efficient in catalyzing the reactions required to sustain the growth and reproduction of the crystal particle. These structures would eventually have displaced those that were less efficient. Thus, inorganic clay minerals would have had a capability for biochemical evolution. Perhaps, as Prof. Weiss suggests, a series of reproduction "errors" led to the appearance of an organism which could store genetic information in RNA or DNA. Nucleic acids can store more genetic information than could be contained by mineral crystals, and can direct the synthesis of complex enzyme molecules with

greater catalytic activity and specificity. The DNA molecule thus offers more scope for biochemical evolution. Once organisms appeared which could utilize DNA to store genetic information and direct protein synthesis, they would soon replace their predecessors and drive them to extinction.

The appearance of life would have eliminated the very conditions that were essential for its creation. Primitive forms of life could only appear when there was an abundant supply of nutrients, a source of chemical energy that could be exploited, and conditions that were otherwise very favourable. Where such abundant sources of nutrients now arise, they are almost immediately consumed by existing organisms. Should an unusual series of chance events give rise—once again—to a primitive precursor of life, it could not possibly compete with present-day organisms (whose ability to exploit such environments has been honed after many millions of years of evolution).

Primitive organisms using inorganic crystals (rather than enzymes) to catalyze reactions might have served as a "missing link" in the development of life, filling a prominent gap in the present theory of how life originated. There is general agreement that life appeared within the first billion years after the Earth was formed (the first fossil evidence of single-cell organisms are found in sedimentary rocks formed about 3.6 billion years ago). The atmosphere of the primordial Earth probably consisted largely of methane, ammonia and water. The action of ultraviolet light in solar radiation, electrical storms and volcanoes evidently reformed these compounds into a liquid "soup" of amino acids, sugars and other important biochemical building blocks. Recent experiments, which have attempted to simulate conditions on the primordial Earth, have demonstrated that most amino acids, sugars and nucleotide bases can readily be formed when a few simple gases are subjected to ultraviolet light, heat or an electrical discharge in an oxygen-free atmosphere. Meteorites striking the Earth might have also contributed some organic matter to the primordial soup.

The formation of a prebiotic soup is now generally accepted as the first step in the evolution of life. But the next step is more difficult to explain. How did the amino acids, sugars and nucleotides in the prebiotic soup assemble to form organisms which could survive and reproduce offspring with the same chemical make-up. After all, an organism able to produce even a few enzymes requires an extremely high level of complexity and order. For the enzymes and other proteins to perform the functions for which they are needed, their constituent amino acids must be assembled in the correct sequence and configuration. A great deal of information is required to direct the synthesis of protein molecules. Only RNA and DNA molecules have the capacity to encode

*"Replication and evolution in inorganic systems", by Armin Weiss, *Angewandte Chemie Int. Edition*, Vol. 20, No. 10 (1981) pp. 850-860.

this amount of information. To direct the synthesis of enzymes, thousands of nucleotide base pairs must be present along the RNA chain in exactly the correct sequence. It would have been virtually impossible for a particular sequence of nucleotide bases to have originated by chance (see discussion about "the origin of life" in *Chemistry International*, 1981, No. 6).

To account for the simplicity that must have characterized the first "living" organisms, investigators have suspected that these organisms utilized metal ions or inorganic compounds to catalyze reactions. It is known, for example, that divalent zinc is a specific catalyst for polymerization of the nucleic acid guanine. So too are some silicate minerals, such as montmorillonites, excellent catalysts for many organic and inorganic reactions. They can selectively adsorb certain amino acids, form polypeptides from ammonium salts of amino acids, and catalyze a wide range of isomerization and redox reactions.

Montmorillonites are, in fact, widely used industrially as a specific catalyst for the dimerization of unsaturated fatty acids. The fatty acids diffuse between layers of the crystal structure, where they come in contact with Lewis base sites at which Si^{4+} has been replaced by Al^{3+} . Substitution of Al^{3+} for Si^{4+} (or Mg^{2+} for Al^{3+}) imparts a negative charge at that site in the crystalline layer, which is balanced by Na^+ and K^+ ions in the interlayer spacing. The resulting electric field holds the crystal together and is responsible for its catalytic activity.

Electrostatic interactions account, for example, for the selective cleavage of protein molecules in montmorillonite crystals which contain H_3O^+ ions in the interlayer spacing. Once a protein molecule diffuses into the interlayer space, hydrogen ions react with free amine groups (present in the amino acids lysine and arginine), causing a positive charge to be localized at various points along the protein chain. These positive charges become bound to the negatively-charged sites on the crystal framework. While the protein is bound within the interlayer space, remaining H_3O^+ ions hydrolyze the peptide bonds.

The thickness of the interlayer spacing is determined by the extent of ion substitution, and by the ion concentration of the solution in which the crystal is immersed. In silicate minerals like mica, in which there is extensive substitution of trivalent ions for Si^{4+} , the platelet layers are so strongly held together that there is virtually no interlayer space for entry of water or other molecules. However, the interlayer attraction in montmorillonite is so much weaker, that water can permeate between layers of the crystal. The interlayer spacing increases when the crystal is immersed in dilute salt solution. The crystal swells and, when the salt concentration of the solution is very low, completely separates into free platelets. The platelets recombine into a new crystal when the solution becomes more concentrated.

Reversible disintegration and reforming of montmorillonite particles provides a plausible mechanism whereby tiny crystals of the mineral could have grown new platelet layers, and then separated into a number of independent daughter particles—each with an identical chemical structure. The driving force for replication would have been a change in salinity, possibly brought about by alternating periods of freezing and thawing or by heavy rain and drought. It might, of course, be argued that any organism that needed a change in environmental conditions to reproduce could hardly be called a "living" organism (for this reason, Prof. Weiss refers to such organisms as "protolife" or "a very primitive replicating system"). However, one might easily envisage that such organisms might eventually have developed the ability to control the salt concentration of the medium surrounding the crystal particle, and thus regulate their own reproduction.

It is impossible to say whether particles of clay minerals were actually utilized by primitive organisms to catalyze reactions and store genetic information. What Prof. Weiss *has* convincingly demonstrated is that inorganic minerals *could* have been the precursors of RNA and DNA, encoding the first genetic information within their crystal structure.

Advances in medicine and agriculture stem from knowledge of protein chemistry

Proteins are complicated molecules, and perhaps for this reason, chemists have generally disregarded this extraordinary group of chemical compounds. Study of the chemical properties of enzymes and other proteins has been left almost entirely in the hands of biologists and biochemists. This is most unfortunate, remarked Sir David Phillips (Professor of Molecular Biophysics) in his opening lecture at the 7th National Convention of the Royal Australian Chemical Institute.* He described how the determination of protein structure, once an extremely complex and time-consuming task, is becoming a straightforward and almost routine operation. Further, he pointed to new genetic engineering techniques, which could allow virtually any protein to be mass-produced. These remarkable developments are creating exciting opportunities for chemists to understand, modify and exploit protein chemistry.

Professor Phillip's remarks served as a preface to subsequent lectures and discussion at the RACI conference, providing a perspective from which developments presented at the conference could be analysed and interpreted. The growing importance of protein chemistry was especially evident at the sessions on Medicinal and Agricultural Chemistry. While conference speakers there described a diverse range of research projects, nearly all touched in some way or another on the theme of Prof. Phillip's lecture: that an understanding of protein chemistry is the key to future advances in chemical research.

*The Royal Australian Chemical Institute holds a convention every four years, bringing together participants from its 11 divisions (dealing with analytical chemistry, cereals, colloid and surface chemistry, chemical education, electrochemistry, industrial chemistry, organic chemistry, organometallic chemistry, physical chemistry, polymer chemistry and solid-state chemistry). The 1982 Convention, held in Canberra on 22-27 August, was the first to include a section devoted entirely to Medicinal and Agricultural Chemistry. The Convention is a national meeting, but most of the plenary lecturers were invited from overseas and a number of participants attended from other countries of Australasia.

Less than 20 years have elapsed since the detailed crystalline structure of an enzyme (hen egg white lysozyme) was first determined by X-ray crystallography. Since then, precise structures have been derived for numerous enzymes and other small protein molecules. From the data collected in these experiments, it is now becoming possible for researchers to look at these molecules as a class of compounds and deduce *general* principles about how the conformation of an enzyme molecule affects its reactivity, how an enzyme or other protein binds to a substrate molecule, and how inhibitor molecules can interfere with the normal protein-substrate interaction.

To the first pioneering researchers who began the study of protein structure, it must have seemed remarkable that proteins are so ubiquitous in nature. They are found in all plant and animal cells, where they perform an extremely broad range of functions. However, it is now quite clear, as Prof. David Phillips explained in his plenary lecture, why amino acids can be polymerized into such a wide range of complex molecular structures. Polymerization of amino acids (in precisely the correct sequence) forms a polypeptide chain, which can attain a configuration in which hydrogen bonding links the polypeptide strand to adjacent strands *or* to other parts of the same strand. Hydrogen bonding between amino and

carbonyl groups forms the polypeptide strands into pleated sheets (with strands running parallel, but in the opposite direction) or into a helix. These form the major structural units of a protein molecule.

One may describe the structure of any globular protein in terms of its constituent assemblies of sheets and helices. However, by depicting protein molecules in this way, as Prof. Phillips did with a few examples, one must be careful to avoid the impression that protein molecules are open structures, consisting mostly of empty space. That is entirely misleading. When a complete model of an enzyme or other globular protein is assembled, including side chains projecting from the polypeptide backbone, the molecule is invariably a tightly-packed structure. Any open channels or indentations which may be present in the surface of the molecule are probably essential for its activity. The shape of the indentation would provide exactly the right contour for the enzyme to bind to its substrate molecule.

An interesting observation made by Prof. Phillips is that enzymes which perform the same function in different organisms may have an entirely different composition of amino acids — but yet have remarkably similar structures. Does this mean that the organisms evolved from a common primeval ancestor? Perhaps the enzyme structure of the ancestral organism (achieved after several million years of evolutionary refinement) has been so effective that the same molecular configuration was retained as the organism evolved into separate species. On the other hand, we could speculate that the same enzyme structure had evolved independently in different organisms. If this supposition is correct, then millions of years of genetic variation and natural selection had caused different organisms to converge to the same "right answer" for the protein structure that gives maximum enzyme activity. Whether the same protein structure was reached in this way (through "convergent evolution"), or was retained during "divergent evolution" from a common ancestor, might never be known.

When we speak of "the structure" of an enzyme, it is important to bear in mind that an enzyme does not act as a static, rigid template, as has frequently been suggested in the past. Protein chains can twist and rotate, and in this way, achieve a conformation that forms a perfect "fit" with the substrate molecule. It is now generally accepted that protein molecules are highly mobile structures that undergo complex internal motions — and that this mobility may be essential for the substrate to diffuse to the enzyme's active site (and, equally important, for reaction products to escape back to solution). Indeed, the conformation of an enzyme that actually interacts with a substrate molecule may be somewhat different than the time-averaged structure provided by X-ray or neutron crystallography. Furthermore, the structure derived by diffraction experiments with crystalline enzymes might differ from the structure of free enzyme molecules in solution. For one thing, water molecules become bound to enzyme molecules in solution, altering the shape, charge distribution and local environment within the enzyme molecule.

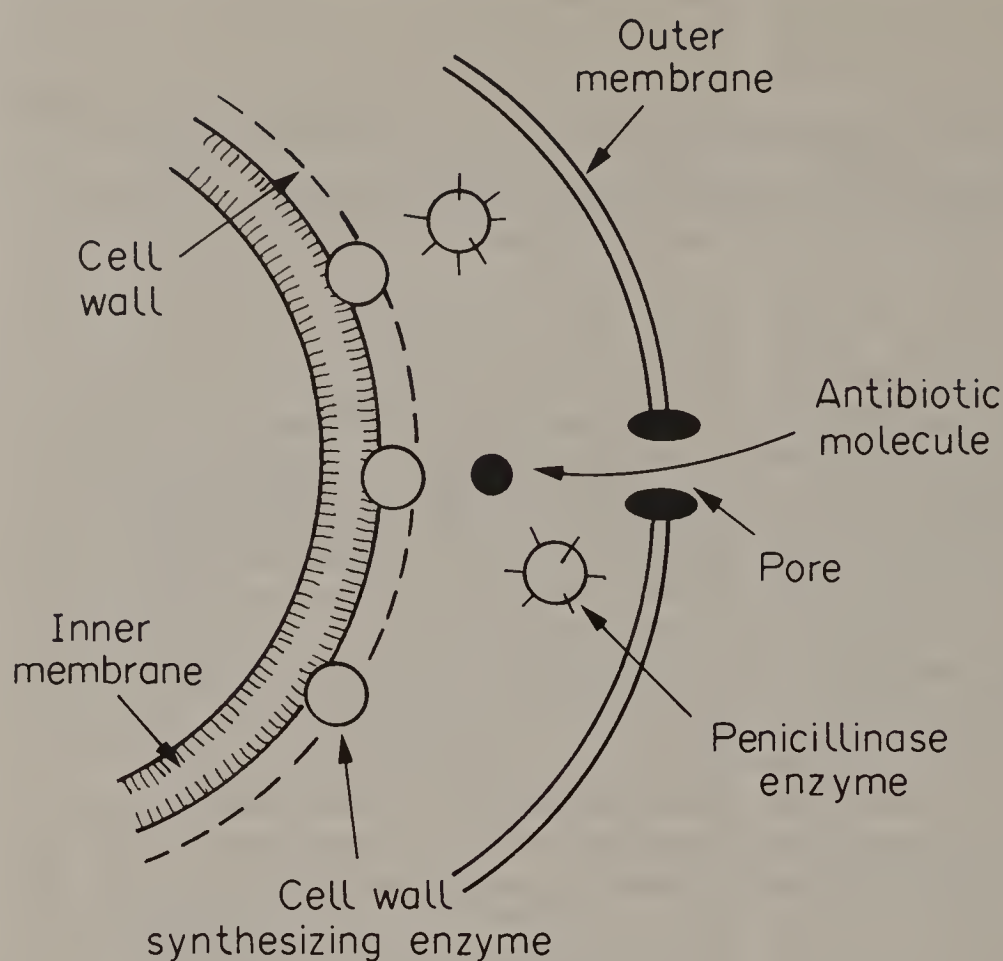
However, it is now becoming possible to develop insight into the motion of an enzyme molecule and its interactions in solutions. By undertaking X-ray dif-

fraction experiments at low temperature, and taking into account information provided by spectroscopic studies of the protein, the researcher can infer how the protein molecule might behave in solution. Such studies will become more and more routine as chemists gain access to new synchrotron particle accelerators (which can be used to generate extremely intense X-rays) and increasingly powerful computers.

Although much progress is being made through *direct* studies of protein structure, the brunt of pharmaceutical and agricultural research focuses on substrate molecules which interact with enzymes or "receptor site" proteins. The researcher probes the active site of the target protein by noting the biological effect of small substrate molecules. Once a compound with some biological activity has been identified, a series of compounds with a similar shape and functional groups can be tested for the same type of activity. The researcher can then determine those structural features of the substrate molecule that are essential for high biological activity, those which have no effect, and those which block entry of the substrate to the active site of the protein.

The relationship between the structure of biologically-active compounds and their activity can be related in a quantitative way with the aid of a computer. Advocates of the QSAR technique (Quantitative Structure-Activity Relationships), like Dr. A. J. Hopfinger (of G. D. Searle & Co., USA), predict that pharmaceutical chemists might routinely predict the biological effect of a new compound (or proposed new compound) by entering its structure into a computer terminal, with no more effort than would now be required to obtain the NMR spectrum of a new compound. However, he warned that QSAR is not the ultimate technique for drug design, and that other methods will be used where they are appropriate. Other QSAR users, like Prof. Garland Marshall (at Washington University in St. Louis, USA), were even more cautious. Prof. Marshall told the Medicinal and Agricultural Section of the RACI Convention that drug structure-activity relationships are only of value to guide the pharmaceutical researcher in selecting the most promising compounds for synthesis and testing. Its predictions, based on a formal mathematical analysis might be no more reliable — and can be just as wrong — as predictions based entirely on intuition. Enzymes and receptor site are notoriously difficult to fool with synthetic drug molecules. Few drug molecules (like the proteins with which they interact) are rigid structures. Even though the drug designer may know the exact structure of a biologically active molecule *in solution*, he can only guess its structure when it is bound to the enzyme or receptor site.

One study, described at the RACI Convention by Prof. Peter Andrews and his coworkers, considered those molecular features that are responsible for the activity of stimulants, depressants and other drugs affecting the central nervous system. It has long been recognized, he pointed out, that all drugs affecting the central nervous system must have sufficient fat solubility to diffuse into the brain from the bloodstream. Furthermore, virtually all analgesic drugs, antipsychotic agents, antidepressants, hallucinogens, anticonvulsants and stimulants contain an aromatic ring and a nitrogen atom. Both of these functional groups seem to be essential for



The target of penicillin and similar antibiotics is the enzyme which synthesizes the cell wall of disease-causing bacteria. In pathogenic gram-negative bacteria, cell wall synthesis occurs at the cell's inner membrane. To kill the cell, the antibiotic molecule must pass through a pore in the outer membrane, and make the treacherous journey through the fluid layer between the inner and outer membrane. Penicillin-resistant bacteria have developed the ability to produce penicillinase enzyme, which intercepts and destroys the antibiotic molecule before it reaches the inner membrane.

To counter antibiotic resistance, drug designers have adopted several strategies. One new approach is to administer a penicillinase inhibitor, which binds to the penicillinase enzyme and thereby allows the antibiotic to carry out its intended mission.

activity, and are clearly involved in binding of the drug to the receptor site at the tip of the nerve cell. All these drug molecules evidently have structural features which are very similar to natural neurotransmitter molecules (which are released by conducting nerve cell fibres, diffuse across the narrow junction at a nerve synapse, and stimulate adjoining nerve cells to fire). The drug molecule becomes bound to the receptor site. There, it either stimulates the nerve cell to fire, or depresses nerve cell activity by blocking the effect of neurotransmitter molecules released by adjoining nerve cells.

Now, Prof. Andrews asked, what is the spatial relationship between the aromatic ring and nitrogen atom in the various types of drugs affecting the brain and spinal cord? Could the orientation of the aromatic ring, relative to the nitrogen atom, be responsible for the different types of activity (say, between a stimulant and a depressant)?

Prof. Andrews described how his group (at the Victorian College of Pharmacy in Melbourne, Australia) discovered — to their surprise — that the aromatic ring and nitrogen atom were nearly superimposable in *all* the drugs they investigated. Consequently, they postulate that the different types of activity on the central nervous system was not due to different positions or orientations of *these* two groups within the molecule, but could be attributed to other functional groups or structural features. To support this argument, Prof. Andrews pointed to the completely opposite biological effect (convulsant and anticonvulsant activity) induced by two optical isomers of the same barbiturate compound. These compounds differ only in that the position of a hydrogen atom and a methyl group are interchanged.

This led Prof. Andrews (in collaboration with colleagues in Adelaide, Australia and the USA) to consider the subtle differences in molecular structure that cause some barbiturate drugs to exhibit convulsant activity, and others to be anticonvulsants. Both types of drug would presumably be bound to the receptor site in exactly the same way (through the aromatic ring and nitrogen atom). In all *convulsant* drugs considered in their computer graphic study, one part of the molecule could always project into a particular region of space at the receptor site. *Anticonvulsant* barbiturates have no substituents in this region (except perhaps when the molecule is twisted to a high-energy conformation). In fact, they showed, anticonvulsants have substituents which occupy an entirely separate region of space. This suggests to Peter Andrews, Graham Jones, David Winkler and L. C. Mark that chemical groups projecting into these two regions of space determine whether a barbiturate compound acts as a convulsant or an anticonvulsant.

In the case of drugs affecting the central nervous system, the receptor binding site is poorly understood. Virtually all that is known about the receptor has been inferred from its interaction with drug molecules. In other cases, where the drug functions by binding to an enzyme, much more is known. It may be possible to extract the enzyme, and systematically study its interaction *in vitro* with a prospective drug molecule. A good example is the action of penicillin antibiotics, which interfere with bacterial growth by binding to an enzyme necessary for synthesizing the bacterial cell wall. Unable to synthesize the material composing its cell wall, a bacterial cell cannot grow, maintain its physical

structure or resist changes in osmotic pressure of the surrounding solution. The bacterial cell dies, and the infection is halted. Penicillin antibiotics (and related cephalosporin antibiotics) are extremely selective in their toxicity. While they are very toxic against bacterial cells, they are almost completely innocuous to animal cells. The reason is simple: animal cells do not have, or need, a cell wall.

But all is not well on the antibiotic scene. As early as 1940, pathogenic bacteria were beginning to appear that were resistant to penicillin. These bacteria were developing penicillin resistance by three alternative routes. Some had evolved a new enzyme for cell wall synthesis which is less strongly bound to penicillin. Others underwent a change in their outer membrane, so that antibiotic molecules could not readily penetrate to the inner membrane at which cell wall synthesis takes place. The third mechanism of penicillin resistance, which proved to be by far the most important, is the production of a new penicillin-destroying enzyme by the bacterial cell. This "penicillinase" enzyme breaks open the B-lactam ring of the antibiotic molecule, converting it to a product which is harmless to the bacterial cell. Once a bacterial strain develops the ability to make penicillinase, as much as 500 times greater concentration of antibiotic is necessary to kill the bacterial cells.

Soon after the penicillinase enzyme was identified as the primary cause of penicillin resistance in pathogenic bacteria, drug designers considered various ways in which they might neutralize its effect. The strategy that was generally adopted was to alter the structure of the antibiotic molecule so that it would not fit in the active site of the penicillinase enzyme (but *did* bind to the enzyme which makes the bacterial cell wall). This strategy was successfully employed for many years, culminating in the development of cephalosporin antibiotics which are virtually invincible against penicillinase attack. However, since the mid-1970s, pharmaceutical researchers have adopted an entirely new strategy in the war against bacteria. The rationale of this new approach was outlined by Dr. Jeremy Knowles (of Harvard University, USA).

The new strategy, Dr. Knowles explained, was to administer a conventional penicillin antibiotic with a "penicillinase inhibitor", a molecule which binds to the penicillinase enzyme and incapacitates it. Thus, instead of engineering one compound which has the two properties needed in an effective antibiotic (disruption of cell wall synthesis and protection against penicillinase), the drug designer can optimize these properties independently in two separate compounds.

Some enzyme inhibitors form a strong bond to the active site of the enzyme, where they remain for many hours or days. Such compounds are called "suicide inhibitors", although this term is somewhat misleading: they are really enzyme killer molecules. Once the inhibitor binds to the active site, the enzyme is unable to function and is effectively destroyed.

However, a penicillinase inhibitor need not bind irreversibly to protect an antibiotic, Dr. Knowles emphasized. The first inhibitor-antibiotic combination to be introduced will contain clavulanic acid, a compound which becomes bound to penicillinase for only a few hours before it is destroyed by the enzyme. The fact that clavulanic acid is eventually decompos-

ed by penicillinase does not, as it turns out, restrict its ability to protect penicillin antibiotic (which is administered at the same time). To destroy an enemy bacterial cell, he later explained by analogy, one need only distract its "anti-aircraft gunners" (penicillinase enzyme molecules) long enough for the "bombers" (penicillin molecules) to get through.

The development of combined antibiotic-inhibitor formulations is not expected to provide the ultimate weapon in the enzyme war. For one thing, combination drugs are much more expensive to test and register, since the pharmaceutical company must conduct clinical trials to establish the safety of the inhibitor and antibiotic, as well as the combination of ingredients. Already, clinical testing is the most expensive and time-consuming phase in the development of new drugs. Perhaps even more important in the long term, bacterial cells will undoubtedly develop new ways of protecting themselves against antibiotics, and new compounds or drug combinations must be introduced to counter resistant bacterial strains that will eventually emerge.

Participants at the Medicinal and Agricultural Section of the RACI conference were well aware that drug design has primarily been concerned with synthesizing substrate molecules that bind enzymes or protein receptor sites in the human body, or in invading bacterial or tumour cells. But it soon became evident that this approach could be radically altered — effectively, turned inside-out — by the advent of recombinant DNA techniques and genetic engineering. Recent developments in this area have demonstrated that it should ultimately be possible for pharmaceutical chemists to synthesize (or manufacture) any protein molecule known to have useful biological activity. Such proteinaceous drugs (like synthetic hormones, for example) could be administered to correct various deficiencies by regulating the metabolism of nutrients, salts and other small substrate molecules in the body.

Many proteins extracted from plants or animal tissue have potent activity that could be exploited for treatment of disease, but are not presently available in sufficiently large amounts to be useful pharmaceutical products. Among the many such proteins likely to have wide clinical applications are Human Growth Hormone, Nerve Growth Factor, ACTH (which is used for treating inflammation and rheumatic disease), eurogastrone (for controlling secretion of stomach acid), and eurokinase (for dissolving blood clots).

Once a protein has been identified as a potentially useful pharmaceutical product, purified, and its structure determined, it is a straightforward process — in principle — to engineer a strain of bacteria or mould to produce this protein. A chemist can synthesize a strand of DNA, whose sequence of nucleotide bases corresponds to the sequence of amino acids in the protein. If the protein molecule is so large that it is impractical to synthesize an artificial gene, then the DNA strand can be excised from chromosomes in the plant or animal cell which normally produces this protein. The DNA strand, whether synthetic or obtained from a plant or animal cell nucleus, can then be inserted into the DNA of a bacteria cell — causing that organism to produce the desired protein. Using this technique, genetic engineering companies have already developed the

Proteins in living cells are studied by NMR spectroscopy

To analyse the molecular structure of a protein using traditional methods (X-ray and neutron diffraction), the protein must first be isolated from the biological source, purified and crystallized. The environment in which the protein structure is studied may be entirely different from the environment around the protein when it is actually performing its role inside the living cell. The experimenter must therefore be cautious when applying diffraction data to explain the interactions of enzymes with substrate molecules in cell fluids or membranes. However, the information gap left by diffraction experiments could be filled by another technique — one which is already well known to chemists, nuclear magnetic resonance (NMR) spectroscopy.

Chemists and biochemists are beginning to recognize the very powerful potential of NMR for studying proteins and macromolecules. It allows the researcher to obtain detailed information about complex molecules and the chemical reactions *inside living cells*. However, many chemists may not be aware that technological improvements in the design of NMR spectrometers has extended enormously the versatility, sensitivity and resolution that can be achieved with this technique. Sophisticated new instruments utilize Fourier-transform spectroscopy (which allows all nuclear spin transitions to be monitored simultaneously), superconducting electromagnets which are far more powerful than those previously available, advanced pulsing techniques and electronic data storage, and high-speed "magic angle" spinning. The new generation of NMR spectrometers can perform experiments that would have been prohibitively difficult or impossible with earlier instruments.

Ten years ago, NMR spectrometers were used almost exclusively to obtain the hydrogen magnetic resonance spectra of relatively simple organic compounds. The use of ^{13}C NMR was considered a very specialized technique. Now, however, one can routinely obtain NMR spectra of ^{13}C , ^{15}N , ^{19}F , ^{29}Si ,

^{31}P or virtually any nuclei with a magnetic moment in the sample. These nuclei, unlike hydrogen, are usually present in only a few different types of chemical environment in the molecule. Consequently, the NMR spectra are often relatively simple to interpret — even for complex biological samples.

Because the sample in an NMR spectrometer is exposed only to radiofrequency radiation in a powerful magnetic field, there is no damage to the sample. The cells, and their protein constituents, function in the normal way while a spectrum is being recorded. Nuclear magnetic resonance is not only a powerful tool in the hands of the researcher, but could also be widely used in medicine to examine internal organs in human patients. It could augment, or possibly even replace, diagnostic X-rays. So far, there is no evidence that the radiofrequency and magnetic fields used in NMR comprise any health hazard (as do X-rays).

While the new generation of sophisticated NMR spectrometers are far more powerful than those available a decade ago, they are also far more costly. Not every research laboratory could, or should, afford one. However, cooperative ventures undertaken by several laboratories can ensure that these facilities are available to all researchers who need them. One example is the NMR Centre recently established by three universities in Brisbane, Australia (the University of Queensland, Griffith University and Queensland Institute of Technology). The three institutions have contributed funding for the purchase and maintenance of an advanced NMR instrument, which is available to faculty in all three universities (and to other laboratories, for a fee). Each university is equipped with a first-generation NMR instrument for routine samples. It is therefore not surprising that chemists and biochemists at these universities make extensive use of NMR in a wide range of research projects, and that the University of Queensland would be the venue for a Symposium on

technology to mass-produce human insulin (diabetics have formerly relied on insulin extracted from pig pancreas cells), interferon and vaccine for hoof-and-mouth disease. Research programmes presently underway are expected to yield a wide range of other new products.

But has the importance of genetic engineering been overstated? Some researchers argue that the same results could often be achieved as effectively by alternative means. For example, one participant at the Medicinal and Agricultural Chemistry session questioned the need for genetic engineering companies to mass-produce human insulin (by inserting the gene for production of human insulin into bacterial cells). Presumably, insulin made in this way would have less side-effects for diabetics than insulin derived from pigs. However, pig insulin differs from human insulin in only one amino acid comprising the protein molecule. In fact, pig insulin can be converted to

human insulin by cleaving this amino acid from the molecule and replacing it with the correct amino acid. So does it make sense to produce human insulin using recombinant DNA techniques, the participant asked during a discussion session, when the same product can be made by conventional chemical techniques?

Perhaps not, replied Nancy Millis (from the Department of Microbiology at the University of Melbourne), opening speaker at the session on "Genetic Engineering for Beginners". She felt that genetic engineering researchers should concentrate their efforts on making products that could not be made in any other way. She questioned recent attempts to engineer new cereal strains with a high lysine content. Although many cereal plants do not contain enough lysine for good nutrition, lysine can be readily produced in large quantities by conventional fermentation technology. If we are concerned

NMR of Synthetic and Biological Polymers (held 27 and 28 September).

One speaker, Prof. Burt Zerner, reported to the symposium that the advent of high-resolution instruments has dramatically accelerated the application of NMR spectroscopy to the study of enzymes. However, although he stressed the extraordinary power of high-resolution NMR to provide insight in protein chemistry, he cautioned against its indiscriminate use. Researchers should not use high-resolution NMR to solve trivial problems, when simpler and less costly instruments could serve equally well. This would be like using a sledgehammer, he alluded, to crack a peanut shell. Prof. Zerner discussed in his talk a few studies in which NMR revealed important information about enzyme catalysis and protein structure.

One example he selected was a study undertaken by his own group (in the Biochemistry Department at the University of Queensland). They had previously shown that benzil was a powerful inhibitor of a carboxylesterase enzyme, and decided to synthesize structurally-similar compounds containing fluorine atoms. They were able to study enzyme inhibition by monitoring the ^{19}F NMR spectrum of these compounds, and the complexes they formed with the enzyme. Fluorine is a particularly suitable NMR probe, Dr. Zerner pointed out, since ^{19}F comprises nearly 100% of fluorine atoms in a normal sample. The sensitivity with which ^{19}F nuclei are measured is nearly as high as the sensitivity obtained in hydrogen NMR. Furthermore, one can usually distinguish different fluorine atoms in a molecule, since the position of an ^{19}F nucleus in the NMR spectrum is strongly dependent upon its chemical environment in the molecule. Of course, fluorine atoms are rarely found in complex molecules of natural origin. This is sometimes an advantage, as it allows the researcher to introduce fluorine at a selected site in a substrate molecule. When Prof. Zerner's group tested the compound 3,3,3-trifluoro-2,2-dihydro-1-phenyl-1-propanone, they found that this molecule is one of the most powerful enzyme inhibitors yet discovered. By examining the ^{19}F spectrum of the enzyme-inhibitor complex, they were able to show that most inhibitor molecules were bound to two sites in the

enzyme, although some singly-bound inhibitor was also evident in the ^{19}F NMR spectrum.

In another study cited by Prof. Zerner, the mechanism of enzymatic phosphorylation (a key step in protein synthesis) was investigated by ^{31}P NMR. Prof. Zerner pointed out that ^{31}P is an ideal NMR probe for studying cellular metabolism. Phosphoric acid esters are important metabolites and cell regulators, and nearly all phosphorus atoms normally present are the ^{31}P isotope. Its nuclear spin of 1/2 (and the resulting absence of quadrupole broadening) make ^{31}P NMR spectra relatively easy to interpret. The absorption signal of ^{31}P is only about 7% of that obtained with hydrogen NMR, but this poses little difficulty with high-sensitivity Fourier-transform NMR spectrometers.

^{31}P NMR is also being exploited as a probe of heart muscle metabolism by Dr. Roger Willis and coworkers at Griffith University. They are studying the effect of a temporary interruption of blood supply to the heart. They surgically remove the heart of a guinea pig, insert the entire organ into an NMR sample probe, and keep the heart muscle alive — and still beating — by providing a supply of oxygen and nutrients. When the flow of oxygenated perfusion fluid is interrupted, they monitor the depletion of the cellular energy source adenine triphosphate (ATP), or can observe the accumulation of phosphate and other metabolic end-products.

They reported to the symposium that the ^{31}P NMR spectrum of the heart clearly shows that the supply of ATP is rapidly depleted when the flow of oxygenated fluid is interrupted. If the flow is restored within a short time (about one minute), the concentrations of ATP and phosphate metabolic products rapidly revert back to their original levels. During the period of oxygen deprivation, the heart may miss several beats. This behaviour may, in fact, be a protective mechanism that enables the heart muscle to cope with short periods of oxygen deprivation. When Dr. Willis' group artificially induced the heart to beat at regular intervals (by electrical stimulation with a pacemaker), the heart muscle required a much longer time to restore the ATP concentration to its original level.

about lysine deficiency in the diet, she queried, couldn't lysine be added directly to food products made from existing cereal plants?

One of the most promising areas for the application of genetic engineering technology seems to be the production of improved vaccines. Conventional vaccines contain dead cells of bacteria (or virus particles) that induce the production of antibodies. If the body is subsequently invaded by bacteria of the same type, the antibodies will recognize, engulf and destroy the invading bacteria cells. What enables the body to recognize foreign cells, and produce antibodies specifically tailored to destroy them, are proteins at the surface of the pathogen. Consequently, it should be possible to induce immunity to a disease without exposing the individual to entire cells (either living or dead). The protein at the surface of the bacterial cell should, by itself, induce the formation of antibodies. The approach of the genetic

engineer is to isolate from the disease organism the gene governing production of proteins in the cell membrane. This gene is inserted into an innocuous organism, causing it to mass-produce the surface proteins characteristic of the disease organism. Injection of the isolated proteins should elicit the same immune response, presumably without the side-effects or severe reactions that occasionally follow an immunization. This method of producing vaccines appears to be inherently safer and more efficient, but as Dr. Millis pointed out, no one yet knows if vaccines produced by recombinant DNA techniques will be as effective as conventional vaccines.

Recombinant DNA research has also provided insight into the cause and prevention of infectious diseases in plants. In fact, the flow of technology has gone in both directions: the study of plant diseases has provided genetic engineers with one of their most powerful tools for transferring genetic information

between organisms. Recombinant DNA researchers have come to rely on agrobacteria, such as those causing plant cancers, to alter the genetic make-up of plant cells. As Dr. Max Tate (of the Waite Agricultural Research Institute in Adelaide, Australia) pointed out, agrobacteria are masters of genetic engineering. They inject DNA into the infected plant cell, causing it to produce nutrients specifically needed by the agrobacteria to sustain its growth. The infected tissue forms a tumourous growth, greatly reducing the yield and economic value of the crop plant.

However, not all agrobacteria are harmful to the plant. Some strains produce antibiotic compounds which prevent infection by pathogenic strains of the same bacteria. Of course, many microorganisms produce antibiotics that are effective against competing organisms — but what is unique about agrobacteria is that they can produce antibiotics that are effective against different strains of the *same* bacteria. This extraordinary degree of selective toxicity is now exploited to protect crops against outbreaks of “crown gall disease”, “hairy root disease” and other agrobacterial infections. By dipping each seedling into a solution containing an innocuous strain of agrobacteria, the plant acquires lifetime immunity

against destructive agrobacterial infection.

The main application of recombinant DNA research in agriculture, using agrobacteria and other methods of implanting genes into plant cells, is to produce superior plant strains — those with more resistance to insects or drought, requiring less fertilizer, or producing cereals and vegetables that are more nutritious or appealing. We should not however, in the view of Dr. Wayne Gerlach (of CSIRO's Division of Plant Industry), expect genetic engineering to replace alternative plant breeding techniques. Conventional methods of plant breeding are slow but, he emphasized, they have yielded impressive results. *All* present crop plants have been bred from wild plant varieties; usually with an enormous enhancement in yield and improved physical properties. To bring about genetic change at a much faster rate than occurs naturally by spontaneous mutations, agricultural researchers may exploit new techniques for growing isolated plant cells in tissue culture. For reasons that are not understood, a high incidence of genetic mutations occur when undifferentiated plant cells are grown in culture. This “somoclonal variation” might allow new plant varieties to be generated and selected at a more rapid rate than has previously been possible.

Erratum

Chemistry International, 1982, No. 5, p. 20. The Recent Report entitled ‘Recommended approaches to the production and evaluation of data on pesticides’ should read ‘Recommended approaches to the production and evaluation of data on pesticide residues in food’.

Chemistry International Subject Index 1979-1982

Articles which have appeared in *Chemistry International* have spanned many subject areas. Each article provides comprehensive coverage of a particular aspect of the subject, and contains background information necessary for a reader to understand and interpret these developments. When articles dealing with any one subject are considered collectively, they provide an overview which is seldom available from other chemistry magazines or journals.

Presented here is a cumulative index of articles published in *Chemistry International* during the last 4 years. It is presented not merely as a compilation of articles that have been published, but as a guide for readers to relate material presented in different issues and "re-package" the information for use by their students, colleagues or themselves.

ATMOSPHERIC CHEMISTRY

Removal of CO, NO_x and SO₂ from atmosphere hinges on OH radicals produced from ozone. 1982, No.4, pp.10-11.

Atmospheric chemistry of the planet Venus. 1980, No.1, pp.20-25.

Good news about carbon monoxide. 1980, No.1, pp.5-6.

Major changes in food and fibre production will follow rising carbon dioxide levels in air. 1979, No.2,* pp.9-10.

Caution: nuclear war can be hazardous to health (by destruction of ozone layer). 1979, No.1,* p.6.

ATOMIC WEIGHTS

A new concept alters the way chemists view "atomic weights". 1980, No.4, pp.9-10.

A massive problem with atomic weights (Letter). 1982, No.2, pp.8-9.

More on atomic weights (Letters). 1982, No.5, p.2.

Variation of atomic weights are accounted for by proposed changes. 1979, No.1,* pp.6-7.

BIOTECHNOLOGY

Advances in medicine and agriculture stem from knowledge of protein chemistry (Proteins in living cells are studied by NMR spectroscopy). 1982, No.6, pp.8-14.

Synthesis of complex chemical products is feasible with new enzyme techniques. 1982, No.6, pp.4-5.

Enzymes are the key for rapid, specific chemical analysis. 1982, No.3, pp.11-13.

Microbiologists discover that bacteria have remarkable ability to adapt, cooperate — and even change lifestyle. 1982, No.1, pp.2-4.

Fermentation converts chemical waste to fuel, food and feedstocks. 1980, No.6, pp.3-4.

Biotechnology opens route from biomass to fuel (Anaerobic bacteria convert biomass to methane). 1980, No.2, pp.6-8.

Upgrading wastes to high-grade fuel entices developers of biogas. 1979, No.3, pp.17-21.

see (NEW) FOOD PRODUCTS, CHEMICALS FROM BIOMASS

CATALYSIS

Technical breakthrough opens way for cheap solar cells and new photocatalysts, keynote speaker reports at IUPAC Congress. 1981, No.6, pp.13-18.

Catalyst activity is modified by presence of reacting molecules. 1981, No.1, pp.10-11.

Zeolite catalysts with new properties offer improved reaction yields. 1979, No. 2,* pp.6-8.

CHEMICAL ANALYSIS

Trace analysis poses unsuspected pitfalls for the complacent analytical chemist (Reliability of trace analysis is prime concern of IUPAC Toxicology Commission). 1982, No.4, pp.8-10.

Detector tubes allow simple, low-cost analysis of gases and vapours. 1982, No.4, pp.12-16.

Enzymes are the key for rapid, specific chemical analysis. 1982, No.3, pp.11-13.

The photoelectron microscope reveals surface structure and chemical composition. 1982, No.3, pp.4-8.

Chemical analysis through the electron microscope. 1982, No.2, pp.6-7.

New ion-selective electrodes allow simple chemical analysis, fast results. 1982, No.1, pp.13-18.

Trace compounds in gases are detected by selective excitation with excited nitrogen molecules. 1982, No.1, pp.5-6.

Simplified chemical tests can support medical services in remote areas (Immunoassay tests in a portable laboratory kit allow rural health workers to diagnose disease). 1981, No.6, pp.3-10.

Neutron activation analysis: a powerful technique becomes available to chemists. 1981, No.5, pp.13-19.

Standard tests are evaluated for analyzing trace metals. 1981, No.2, pp.2-5.

Recent studies probe molecular structure with neutrons. 1980, No.3, pp.30-34.

Metal impurities are detected with 100x more sensitivity after preconcentration. 1979, No.2,* pp.11-13.

Less food spoilage could result from wide use of new copper test. 1979, No.1,* p.3.

CHEMICAL DATA

Data compilation: 100 years of chemistry at your fingertips. 1982, No.4, pp.23-24.

Finding data in the chemical haystack: an international approach to the problems. 1980, No.5, pp.10-11.

Will a rising tide of information conceal what we need to know (Editorial). 1980, No.3, pp.1-2.

IUPAC launches its largest project to collect and evaluate data. 1979, No.3, p.7.

CHEMICAL EDUCATION

Television, audiotapes and chemistry kits are integrated into innovative chemistry courses. 1982, No.5, pp.10-14.

The ability to solve problems is fundamental for success in chemistry, believes chemical education researcher. 1982, No.3, pp.1-3.

Home-made chemical instruments upgrade laboratory training at low cost. 1982, No.1, pp.7-12.

IUPAC Chemical Education Committee copes with spreading fame, shrinking funds. 1982, No.1, p.24.

Pilot programmes attempt to bridge the industry-university chemistry chasm. 1980, No.5, pp.1-4.

An active student role is key component of a novel teaching approach (a new method allows students to perceive atomic orbitals). 1980, No.3, pp.13-14.

A mobile chemistry laboratory brings chemistry to rural students. 1980, No.1, p.18.

CHEMICAL INSTRUMENTATION

Microprocessor control of instruments alters the role of the chemical analyst. 1982, No.4, pp.6-7.

Cheap home-made polarograph provides good analysis results (Letter). 1982, No.4, p.7.

The photoelectron microscope reveals surface structure and chemical composition. 1982, No.3, pp.4-8.

Good prospects reported for major advances in atomic absorption/emission spectroscopy (Chemical analysis through the electron microscope). 1982, No.2, p.7.

Home-made chemical instruments upgrade laboratory training at low cost. 1982, No.1, pp.7-12.

A new invention may open the way for studies of low-temperature chemistry. 1980, No.1, pp.9-10.

A promising new technique can analyze and separate dust components. 1979, No.3, pp.14-15.

CHEMICALS FROM BIOMASS

Break-down of cellulose is key step in making chemicals from biomass. 1981, No.5, pp.7-8.

Agriculture could provide chemicals to nurture Third World Industries. 1981, No.4, pp.21-24.

Supplies of aromatic chemicals hinge on coal, wood and waste. 1980, No.6, pp.16-22.

Agricultural products — raw material and energy source of the future (Complex chemicals will be extracted from plants, made by microorganisms). 1980, No.5, pp.17-25.

Liquid fuel is produced from waste by direct thermochemical reaction. 1980, No.4, pp.20-24.

CHEMICALS FROM COAL

Coal-derived liquid fuels provide hydrogen for fuel cell power, vehicle propulsion. 1981, No.5, pp.20-26.

Gasified coal — starting point for chemical manufacture. 1980, No.6, pp.5-11.

Supplies of aromatic chemicals hinge on coal, wood and waste. 1980, No.6, pp.16-22.

Conversion of industry to coal looms as sulfur-removal technology matures. 1979, No.2,* pp.3-4.

CHEMISTRY & ECONOMIC DEVELOPMENT

Chemistry will be the driving force accelerating the development of Asia. 1981, No.4, pp.14-20.

Agriculture could provide chemicals to nurture Third World industries. 1981, No.4, pp.21-24.

Small, multi-product chemical plants use scaled-up laboratory synthesis. 1981, No.3, pp.25-28.

Leading world chemists ponder transfer of chemical know-how. 1980, No.2, pp.17-22.

CHEMISTRY & INDUSTRY

Scientists play a leading role in forming high-technology industries (research-based companies proliferate by technological spin-off). 1982, No.4, pp.1-6.

Small, multi-product chemical plants use scaled-up laboratory synthesis. 1981, No.3, pp.25-28.

A survey of industrial chemists explores their views on IUPAC. 1981, No.1, pp.26-29.

Common interests of the chemical industry will be explored by new IUPAC group. 1980, No.1, p.19.

CHEMISTRY & HEALTH

Simplified chemical tests can support medical services in remote areas (Immunoassay tests in a portable laboratory kit allow rural health workers to diagnose disease). 1981, No.5, pp.3-10.

Prevention of cancer is linked to vitamin C (Editorial). 1981, No.4, pp.1-3.

Hair: A monitor of chemical exposure and disease. 1980, No.6, pp.12-15.

Vinyl chloride: a submerged disaster (occupational disease) is sighted and sunk. 1981, No.1, p.12.

Chemicals and cancer. Part I: the origin of cancer. Part II: Search for the magic bullet. 1980, No.4, pp.11-19.

Incentives are needed for bold research to develop effective new drugs. 1981, No.1, pp.5-7.

The molecular basis of drug action. 1980, No.3, pp.19-24.

Extensive use of vaccines is vital for effective, low-cost health services. 1980, No.3, pp.9-11.

Resolving the dilemma about carcinogens and cancer. 1981, No.3, pp.11-12.

New programs seek effective, low-cost drugs for the Third World (A global affliction may be relieved by novel treatment methods). 1980, No.1, pp.1-5.

Radiotracer studies clarify metabolism of nickel compounds. 1979, No.3, pp.10-12.

CHEMRAWN (CHEMICAL RESEARCH APPLIED TO WORLD NEEDS)

A chemist's "call-to-arms" (Editorial). 1981, No.6, pp.1-2.

CHEMRAWN II: Programme of the International Conference on Chemistry and World Food Supplies. 1982, No.4, pp.28-29.

Chemistry and food supplies are focus of a major IUPAC undertaking. 1980, No.3, pp.6-8.

Chemists must respond to technical challenges of survival. 1979, No.2,* pp.16-18.

New factors influence outlook for organic material supply. 1979, No.1,* pp.11-15.

see CHEMISTRY & ECONOMIC DEVELOPMENT, CHEMISTRY & HEALTH.

CORROSION

How does paint inhibit corrosion? Recent findings disprove old notions. 1980, No.4, pp.5-6.

Greater corrosion resistance imparted by electrodeposition of paint. 1981, No.4, pp.9-11.

ELECTROCHEMICAL ENERGY STORAGE

Progress towards solid-state electrochemical propulsion batteries. 1982, No.3, pp.14-19.

Technical breakthrough opens way for cheap solar cells and new photocatalysts, keynote speaker reports at IUPAC Congress. 1981, No.6, pp.13-18.

Coal-derived fuels provide hydrogen for fuel cell power, vehicle propulsion. 1981, No.5, pp.20-26.

Chemical energy storage provides link for use of solar electric power (Village-scale power generation is key to rural development and industrialization). 1981, No.3, pp.6-9.

Electrochemical propulsion promises fuel efficient transportation (Are electrically-powered cars practical? A few views are discharged). 1980, No.5, pp.5-8.

ENERGY SUPPLIES

The practical use of salinity power. 1980, No.3, pp.24-29.

Greater use of fuel resources highlights need for combustion research. 1980, No.3, pp.15-17.

Emphasis of energy research varies between nations. 1980, No.2, pp.23-27.

The energy "problem" — a challenge for scientists (Editorial). 1980, No.2, pp.1-2.

A global resource could yield energy, but is now discarded into the sea. 1979, No.3, pp.15-16.

A global approach to energy supplies. 1979, No.3, pp.26-27.

New factors influence outlook for organic material supply. 1979, No.1,* pp.11-15.

see CHEMICALS FROM BIOMASS, CHEMICALS FROM COAL

(NEW) FOOD PRODUCTS

A taste of things to come (Editorial). 1981, No.1, pp.1-2.

Microbes upgrade starch to high-protein foods. 1981, No.1, pp.21-25.

Surplus fish is converted to new high-protein foods. 1980, No.6, pp.1-2.

Will protein derived from chemicals be the food of the future? 1979, No.3, pp.12-13.

FOOD POISONS

Mycotoxin food poisoning: an ancient and modern threat. 1980, No.5, pp.26-30.

Nitrosamines as a human hazard. 1980, No.5, pp.31-35.

Natural products are viewed as lethal poisons and carcinogens (Poisonous algae account for outbreaks of seafood poisoning). 1980, No.3, pp.3-5.

INSECTICIDES

Living with pests (Editorial). 1981, No.3, p.1.

Discriminate use of pesticide is vital to future insect control strategy (Clues to pesticide action are gleaned from study of DDT molecule). 1981, No.3, pp.2-5.

Pheromones are key component of new insect control strategy (Pheromones lure fruit flies in Spanish field trials; Forest destruction may be halted by monitoring insect populations). 1981, No.3, pp.19-24.

Simple tests provide accurate results for pesticide residue analysis. 1981, No.1, pp.8-10.

Chemists copy natural compounds to make safer, more effective insecticides. 1979, No.3, pp.5-7.

IUPAC

IUPAC: What it is, What it does, How it works. 1982, No.4, pp.17-25.

New policy encourages wider participation in drafting new nomenclature recommendations (The Chemistry International Experiment). 1982, No.2, pp.25-29.

Basis for individual IUPAC membership approved at General Assembly in Belgium (Bad publicity for IUPAC nomenclature is cited by British National Committee). 1982, No.1, pp.19-24.

IUPAC should focus its resources on fewer projects to meet major needs of the chemical community, Prof. Zollinger recommends at IUPAC General Assembly. 1981, No.5, pp.1-2.

IUPAC conference sponsorship promotes free interaction among chemists (Chaos at a conference, and how to avoid it). 1981, No.1, pp.13-20.

A survey of industrial chemists explores their views on IUPAC. 1981, No.1, pp.26-29.

Where do we go from here? A few ideas for IUPAC. 1980, No.3, pp.38-40.

IUPAC views its future course at (1979) General Assembly Meeting. 1980, No.1, pp.26-29.

LABORATORY SAFETY

The deadly nature of common chemicals (International Programme on Chemical Safety is initiated). 1982, No.5, pp.3-9.

Detector tubes allow simple, low-cost analysis of gases and vapours. 1982, No.4, pp.12-16.

Lab workers cannot rely on toxicity data to avoid exposure to dangerous chemicals (Predicted values of toxicity are unreliable and possibly dangerous, Working Party warns; Good laboratory design and procedures minimize the threat of fire). 1981, No.5, pp.3-7.

Resolving the dilemma about carcinogens and cancer. 1981, No.3, pp.11-12.

How dangerous are laboratory experiments with live bacteria? 1980, No.5, pp.9-10.

An endemic laboratory hazard — mercury poisoning — can be avoided. 1979, No.2,* pp.4-5.

NOMENCLATURE, SYMBOLS & UNITS

An index of chemical nomenclature: Where to find that name, symbol or unit that you're looking for. 1982, No.5, pp.15-19.

IUPAC Chemical nomenclature: a common language for chemists. 1982, No.4, pp.21-22.

Specialized systems for naming chemicals meet diverse needs of nomenclature users. 1982, No.3, pp.9-10.

New policy encourages wider participation in drafting new nomenclature recommendations. 1982, No.2, p.25.

At home with the kilopascal. 1982, No.1, pp.27-28.

Can chemical terminology catch up with 200 years of scientific progress? 1981, No.2, pp.24-28.

Caution: Beware of unnecessary abbreviations (U.A.'s). 1981, No.1, p.32.

A new definition of pH? IUPAC convenes a panel of experts for the acid test. 1980, No.6, pp.23-26.

A few clues, and simple detective work, identify monocyclic compounds. 1979, No.3, pp.8-9.

Better method devised for (naming of) tracer compounds (Extent and location of isotopic substitution are indicated by new naming method). 1979, No.1,* pp.4-5.

Unnilquadium: a new element breaks the name barrier. 1979, No.1,* p.1.

NUCLEAR CHEMISTRY

The birth of nuclear chemistry created opportunities and danger, a pioneer recalls. 1982, No.2, pp.19-24.

Killing tumours with exploding pions (in "Impressions of the IUPAC Congress"). 1981, No.6, pp.25-26.

Nuclear reactors will provide energy to upgrade chemicals, make steel. 1980, No.1, pp.11-13.

Nuclear fusion research poses challenges for chemists. 1979, No.3, pp.22-25.

ORIGIN OF LIFE

Recent evidence points to a strong link between inorganic chemistry and life. 1982, No.6, pp.5-7.

The evolution of life (in "Impressions of the IUPAC Congress"). 1981, No.6, pp.19-21.

Recent clues suggest fresh outlook on how life began. 1980, No.2, pp.3-5.

PLASTICS AND POLYMERS

Polymer chemists collaborate to probe complex processes during polymerization (Structure and properties of plastics are described in reports of IUPAC Working Parties). 1981, No.3, pp.13-17.

Vinyl chloride: a submerged disaster (occupational disease) is sighted and sunk. 1981, No.1, p.12.

A new technique is reported, promising stronger, stiffer synthetic materials. 1980, No.4, pp.3-5.

Training of polymer chemists is tied to trends in the plastics industry (recovery of polymer waste could feed the plastics industry). 1980, No.1, pp.15-17.

Interest on plastic fillers follows wider use of composite materials. 1979, No.1,* p.5.

POLLUTION

Pollution is implicated as sole cause of global lead contamination. 1981, No.4, pp.4-5.

The two facets of phosphate: essential for food production, a threat to the environment. 1981, No.4, pp.25-26.

New chemical processes avert industrial mercury pollution. 1981, No.2, pp.7-14.

Heavy metals: the good, the bad and the ugly. 1980, No.2, pp.9-10.

Cadmium surfaces worldwide as a new pollution danger. 1979, No.2,* pp.19-23.

PRESENTING RESEARCH RESULTS

The hazards and benefits of being understood (Editorial). 1981, No.2, pp.1-2

Writing technical articles to be read and understood. 1981, No.2, pp.15-22.

Photography in the laboratory. 1982, No.2, pp.10-18.

Preparing "camera-ready" copy for rapid publication of research articles. 1980, No.4, pp.7-8.

Publishing without printing (in "Impressions of the IUPAC Congress"). 1981, No.6, p.23.

Speak, and be heard (Editorial). 1982, No.1, p.1.

Presenting your research results: a manual for chemists presenting papers at international chemistry conferences. 1980, No.2, pp.11-16 (reprinted in 1981, No.3, pp.29-34).

Presenting test results as legal evidence: The chemist in court. 1981, No.5, pp.9-12.

THE ROLE & RESPONSIBILITY OF CHEMISTS IN SOCIETY

The ability to solve problems is fundamental for success in chemistry, believes chemical education researcher. 1982, No.3, pp.1-3.

Presenting Scientific Results

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III. EXPLAINING YOUR RESULTS

- Speak, and be heard
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Serendipity: the raw material for scientific discovery (Extraordinary coincidences underlie many fundamental scientific discoveries). 1982, No.3, pp.20-25.

Work should not be sole interest and source of self-esteem, psychiatrist warns. 1982, No.1, p.4.

The management of research projects. 1981, No.6, pp.11-12.

The chemist in court (The growing role of science in the law; Presenting test results as court evidence; Assessment of results by cross-examination). 1981, No.5, pp.9-12.

Global and regional problems are assessed for cooperative action. 1981, No.1, pp.3-5.

Pilot programmes attempt to bridge the industry-university chemistry chasm. 1980, No.5, pp.1-4.

The man who hoped that science could lead where diplomacy would falter. 1981, No.3, pp.35-38.

Keeping the record straight for future chemistry historians (Editorial). 1980, No.4, pp.1-2.

The door closes for new faculty posts, but the jolt is not yet felt. 1980, No.1, pp.14-15.

Low mobility of research staff elicits call for corrective measures. 1981, No.3, pp.9-11.

SOLAR ENERGY CONVERSION & STORAGE

Technical breakthrough opens way for cheap solar cells and new photocatalysts, keynote speaker reports at IUPAC Congress. 1981, No.6, pp.13-18.

Chemical energy storage provides link for use of solar electric power (Village-scale power generation is key

to rural development and industrialization). 1981, No.3, pp.6-9.

Photochemical engines could produce power directly from sunlight. 1980, No.3, pp.11-12.

Chemically-improved photosynthesis could be the key to solar-derived fuels. 1979, No.3, pp.2-4.

SOLID-STATE ELECTROCHEMICAL DEVICES

Progress towards solid-state electrochemical propulsion batteries. 1982, No.3, pp.14-19.

Electrochemical components take a place alongside the silicon chip. 1981, No.4, pp.5-8.

STANDARD TEST METHODS

Standard test methods: common ground for chemical research. 1982, No.4, pp.22-23.

Standard tests are evaluated for analyzing trace metals. 1981, No.2, pp.2-5.

Standard test methods aid research, assist international trade. 1980, No.3, pp.17-18.

SURFACE CHEMISTRY

The photoelectron microscope reveals surface structure and chemical composition. 1982, No.3, pp.4-8.

Wide use of surface chemistry probes require uniform presentation of results. 1980, No.1, pp.7-8.

*The first two 1979 issues of Chemistry International were published under the title "IUPAC Information Bulletin".

CONFERENCES

IUPAC meetings are indicated in bold type

Additional information from address in parenthesis

1983

PACIFIC SCIENCE

February 1 - 11. 15th Pacific Science Congress, This Congress is being sponsored by the Royal Society of New Zealand and the University of Otago. The Theme is "Conservation, Development and Utilisation of the Resources of the Pacific". (Secretary-General, 15th Pacific Science Congress, P.O. Box 6063, Dunedin, New Zealand.)

MASS SPECTROMETRY

February 7 - 11. 8th Conference of the Australian and New Zealand Society for Mass Spectrometry. Melbourne, Australia. (Secretary, ANZSMS Conference, Chemistry Department, Monash University, Clayton, Victoria, Australia.)

OILS, FATS & WAXES

February 13 - 17. International Conference on Oils, Fats & Waxes. Auckland, New Zealand. (Mr. S. G. Brooker, Department of Chemistry, University of Auckland, Private Bag, Auckland, New Zealand.)

HYDRAULIC CEMENTS

February 16 - 17. Discussion Meeting on Technology in the 1990s: Developments in the Science and Technology of Hydraulic Cements. London, UK. (Miss C. A. Johnson, The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG, UK.)

COOPERATIVE EDUCATION

February 21 - 25. World Conference on Cooperative Education. Melbourne, Australia. (The Chairman, World Conference on Cooperative Education, POB 218, Hawthorn 3122, Australia.)

WATER TECHNOLOGY

March 1 - 4. International Water Technology Exhibition and Conference - AguaMex '83. Mexico City. (Ian North, World Water P.O. Box 101, 26 Old Street, London EC1, UK or Denise Smith, Bryant and Associates Inc., 2650 Fountainview, Suite 120, Houston, TX 77057, USA.)

METALLIC CORROSION

March 2 - 3. Symposium on Prevention of Metallic Corrosion "An Element of a Raw Materials and Energy Conservation Policy". Luxemburg. (C. Cabrillac, CEFRACOR, 28 rue Saint-Dominique, F-7500 Paris, France.)

ESSENTIAL OILS

March 13 - 17. 9th International Congress of Essential Oils. Singapore. (9th International Congress of Essential Oils, Suite 1106 World Trade Centre, No. 1 Maritime Square, Singapore 0409.)

AMERICAN CHEMICAL SOCIETY

March 20 - 25. 185th ACS National Meeting. Seattle, USA. (A. T. Winstead, ACS, 1155 - 16th St. N.W., Washington, DC 20036, USA.)

AGRICULTURAL RESEARCH

March 21 - 25. CSIRO International Symposium on Agricultural Research for Tropical North-Western Australia. Darwin, Australia. (Symposium Secretary, Division of Tropical Crops and Pastures, Charles Darwin Laboratories, Darwin, NT, Australia.)

CORROSION

March 21 - 26. Corrosion 83 International Conference. Anaheim, CA, USA. (Conference Co-ordinator, National Association of Corrosion Engineers, P.O. Box 218340, Houston, TX 77218, USA.)

CHEM/ASIA

April. 3rd General Assembly and 2nd Regional Seminar of the Federation of Asian Chemical Societies. Baghdad, Iraq. (Dr. M. M. Singh, Rubber Research Institute of Malaysia, P.O. Box 150, Kuala Lumpur, Malaysia.)

EFFLUENT TREATMENT

April. Symposium on Effluent Treatment in the Process Industries. Loughborough, UK. (Dr. J. J. Stenhouse, Department of Chemical Engineering, University of Technology, Loughborough, UK.)

LASER CHEMISTRY

April. EUCHEM Conference on Laser Chemistry. Belgium. (Prof. X de Hemptinne, Katholieke Universiteit te Leuven, Laboratorium voor Fysico chemie en Kinetica, Celestijnenlaan 200F, 3030 Heverlee, Belgium.)

ELECTROANALYSIS

April 5 - 8. International Symposium on Electroanalysis in Biomedical, Environmental and Industrial Sciences. Cardiff, Wales. (Dr. J. D. R. Thomas, UWIST, Department of Chemistry, King Edward VII Avenue, Cardiff CF1 3NU, Wales.)

CRYOGENICS

April 7 - 12. International Conference on Cryogenic Fundamentals. Wroclaw, Poland. (B. Stalinski, Institute for Low Temperature and Structure Research, Polish Academy of Sciences, p1. Katedrainy 1, PL-50 350 Wroclaw, Poland.)

CHEMICAL ENGINEERING

April 11 - 13. 6th International Congress in Scandinavia on Chemical Engineering. Copenhagen, Denmark. (Bella Center A/S, Center Boulevard, DK-2300 Copenhagen, Denmark.)

WATER TREATMENT

April 11 - 15. 1983 National Conference of Australian Water and Wastewater Association. Australia. (1983 National Conference Secretary, P.O. Box A232, Sydney South, NSW 2000, Australia.)

ION EXCHANGE MEMBRANES

April 12 - 13. International Symposium on Ion Exchange Membranes. Runcorn, UK.
(Conference Secretariat, Society of Chemical Industry, 14/15 Belgrave Square, London SW1X 8PS, UK.)

RADIATION SOURCES

April 18 - 21. 3rd International Symposium on the Science and Technology of Light Sources.
(J. J. Damelincourt, Centre de Physique Atomique, Universite Paul Sabatier, 118 route de Narbonne, F-31062 Toulouse Cedex, France.)

SCIENCE/SOUTH PACIFIC

May. 53rd Conference of the Australian & New Zealand Association for the Advancement of Science. Perth, Australia.
(ANZAAS, Box 873, GPO, Sydney 2001, Australia.)

LIQUID CHROMATOGRAPHY

May 1 - 6. 7th International Symposium on Column Liquid Chromatography. Baden-Baden, Federal Republic of Germany.
(Gesellschaft Deutscher Chemiker, Abteilung Fachgruppen, Postfach 90 04 40, D-6000 Frankfurt/Main 90, Federal Republic of Germany.)

ORGANIC SYNTHESIS

May 5 - 6. International Seminar on Transition Metals in Organic Synthesis. Interlaken, Switzerland.
(Sekretariat, Institut für organische Chemie, Universität Bern, Freistrasse 3, 3012 Bern, Switzerland.)

CHEMICAL ENGINEERING CONGRESS

May 8 - 11. 3rd Pacific Chemical Engineering Congress. Seoul, Korea.
(Prof. Young Gul Kim, Vice-President, Korean Institute of Chemical Engineers, 35, 5-ka Anam-dong, Sunbuk-ku, Seoul 132, Korea.)

OCCUPATIONAL ACCIDENTS

May 8 - 13. 10th World Congress on the Prevention of Occupational Accidents and Diseases. Ottawa, Canada.
(Canadian Congress Organizing Committee, 500-300 Slater Street, Ottawa, Ontario K1P6A6, Canada.)

MEMBRANES

May 17 - 19. International Symposium on Membranes. Sydney, Australia.
(Prof. C. J. D. Fell, School of Chemical Engineering and Industrial Chemistry, University of NSW, P.O. Box 1, Kensington, NSW 2033, Australia.)

WATER DESALINATION

May 23 - 27. 1st World Congress on Desalination and Water Reuse, Florence, Italy.
(DECHEMA, Attn.: Mrs. L. Schubel, P.O.B. 97 01 46, D-6000 Frankfurt 97, Federal Republic of Germany.)

CORROSION

May 30 - June 2. 4th International Symposium on Corrosion in the Pulp & Paper Industry. Stockholm, Sweden.
(Swedish Corrosion Institute, Box 5607, S-11486, Stockholm, Sweden.)

CHROMATOGRAPHIC DETECTORS

May 30 - June 3. International Conference on Chromatographic Detectors. Melbourne, Australia.
(The Secretary, International Conference on Chromatographic Detectors, University of Melbourne, Parkville, Victoria 3052, Australia.)

MULTICOMPONENT POLYMER SYSTEMS

May 30 - June 3. International Symposium on Phase Relationships and Properties of Multicom-

ponent Polymer Systems. Anacapri-Capri, Naples, Italy.

(Prof. Rosario Palumbo, ITPR, CNR, Via Toiano, 6 - 80072 ARCO Felice (Napoli), Italy.)

IUPAC CONGRESS

June 4 - 12. 29th International Congress of Pure & Applied Chemistry. Cologne, Federal Republic of Germany.

(General Secretariat of the 29th IUPAC Congress, Dr. W. Fritsche, c/o Gesellschaft Deutscher Chemiker, P.O. Box 900440, D-6000 Frankfurt/M 90, Federal Republic of Germany.)

POLYMER SCIENCE

June 6 - 9. Milestones and Trends in Polymer Science: A Tribute to Turner Alfrey. Midland, MI, USA.

(Dr. James K. Rieke, 1702 Building, Dow Chemical Company, Midland, MI 48640, USA.)

DRUG ANALYSIS

June 7 - 10. 1st International Symposium on Drug Analysis. Brussels, Belgium.

(Ms. C. Van Kerchove (Secretary), Societe Belge des Sciences Pharmaceutiques—Belgisch Genootschap voor Pharmaceutische Wetenschappen, rue Archimedesstraat 11, B-1040 Brussels, Belgium.)

POLYETHYLENE

June 8 - 10. Golden Jubilee Conference "Polyethylenes 1933 - 1983: Past, Present and Future". London, UK.

(J. N. Ratcliffe, Secretary General, The Plastics and Rubber Institute, 11, Hobart Place, London SW1W 0HL, UK.)

AROMATIC HETEROCYCLES

June 13 - 17. EUCHEM Conference on Synthetic Uses of Ring-Opening Reactions of Aromatic Heterocycles. Ystad, Sweden.

(EUCHEM Conference, Organic Chemistry 1, Chemical Center, Box 740, S-220 07 Lund 7, Sweden.)

BIOINORGANIC CHEMISTRY

June 13 - 17. 1st International Conference on Bioinorganic Chemistry. Florence, Italy.

(Prof. Andrea Scozzafava, Istituto di Chimica Generale, Facolta di Farmacia, Fia G. Capponi 7, 50121 Florence, Italy.)

SEMICONDUCTOR DEVICES

June 15 - 17. 3rd International Conference on the Numerical Analysis of Semiconductor Devices and Integrated Circuits. Galway, Ireland.

(NASECODE Conference, 39 Trinity College, Dublin 2, Ireland.)

DIFFUSION & FLUID FLOW

June 16 - 18. 2nd International Conference on Boundary and Interior Layers—Computational and Asymptotic Methods. Dublin, Ireland.

(BAIL Conference, 39 Trinity College, Dublin 2, Ireland.)

ZIRCONIA TECHNOLOGY

June 21 - 23. 2nd International Conference in the Science and Technology of Zirconia (ZIRCONIA-83). Stuttgart, Federal Republic of Germany.)

(Nils Claussen, Max-Planck-Institut für Metallforschung, Institut für Werkstoffwissenschaften, Heisenbergstrasse 5, D-700 Stuttgart 80, Federal Republic of Germany.)

Topics of future chemistry conferences to be considered by EUCHEM committee

The idea to convene a series of European-wide chemistry research conferences was proposed nearly 20 years ago by former IUPAC President Sir Harold Thompson. Since then, 134 EUCHEM conferences have been held in 14 countries, covering many aspects of pure and applied chemistry. EUCHEM conferences were intended as a European analogue of the Gordon Research Conferences, which had proved so useful in the USA. They provide an alternative to conventional chemistry conferences, allowing participants to discuss their preliminary ideas and findings on an informal basis. Each conference is held at a location providing a relaxed atmosphere at modest cost. Attendance is limited to about 100 participants. The conference programme allows free discussion without commitment, and there is no publication of the discussion. Conference organizers aim to achieve a good distribution of young and old participants, and a balance of academic and industrial chemists.

EUCHEM conferences differ from their American counterparts in that they are joint European ventures, with conferences held in different countries. Experts from around the world may be invited to speak on the specific topic of a conference, but the participants are mainly European.

In selecting subject areas for EUCHEM conferences, emphasis is placed on those fields undergoing rapid advances. Particular topics are usually not repeated, although there are cases where a series of conferences is thought to be desirable (conferences on bio-organic chemistry and stereochemistry, for example, have been held each year, with the emphasis of discussion varying from year to year). Conferences held this year have dealt with bio-organic chemistry of plants, stereochemistry, molten salts, short-lived species in organic chemistry, magnetic circular dichroism, the chemistry of ion beams, pericyclic reactions, synthesis of low-molecular-weight carbohydrates of biological interest, and the spectroscopy of polymers.

EUCHEM conferences planned for 1983 will cover the following topics (the main organizer is indicated in parenthesis):

- (1) The use of lasers in chemistry (Prof. X. de Hemptinne, University of Louvain, Belgium).
- (2) Organic free radicals (Prof. R. Sustman, University of Essen, FRG).
- (3) Synthetic uses of ring-opening reactions of aromatic heterocycles (Prof. S. Gronowitz, University of Lund, Sweden).

- (4) High resolution electron microscopy in solid-state chemistry (Prof. L. Kihlberg, University of Stockholm, Sweden).
- (5) Computers in chemistry, from conception to preparation (Dr. G. Moreau, Roussel Uclaf, Romainville, France).
- (6) Stereochemistry (Prof. J. Baldwin, University of Oxford, UK).
- (7) Bio-organic chemistry (Prof. A. C. S. Wood, University of Strathclyde, UK).
- (8) New techniques in organic mass spectrometry (Prof. C. Enzell, Svenska Tobaks AB, Stockholm, Sweden).
- (9) Organic and organometallic electrochemistry (Dr. J. Grimshaw, University of Belfast, UK).
- (10) Intermediates and mechanisms in nitrogen fixation processes (Dr. G. J. Leigh, Agricultural Research Unit, University of Sussex, UK).
- (11) C-nitroso compounds (Prof. B. G. Gowenlock, Heriot-Watt University, Edinburgh, UK).

For 1984, planning is already underway for conferences dealing with molecular orientation and association studied by circular and magnetic circular dichroism; physical and organic chemistry of strongly acid and strongly basic media; and theoretical aspects of photochemistry. The EUCHEM organizing committee also expects to convene a conference on the use of synchrotron radiation in chemistry, and another conference is envisaged dealing with fuel cells and solid-state batteries.

The EUCHEM organizing committee meets once each year to make plans for the next two or three years. It is not surprising that, in spite of all efforts to economize, essential organizational costs have risen in recent years. This has been partially offset by grants received recently from the Shell Oil Co., Imperial Chemical Industries, Unilever Ltd, Fisons, the Royal Society of Chemistry, the German Chemical Society, and the Swedish National Committee for Chemistry. At its forthcoming meeting, in February 1983, the EUCHEM organizing committee will consider proposals for additional conferences. Suggestions may be sent to Dr. R. W. Keay at the Royal Society, 6 Carlton House Terrace, London SW1, UK.

SPECTROSCOPY

June 26 - July 1. 23rd Colloquium Spectroscopicum Internationale. Amsterdam, The Netherlands.

(23rd CSI, c/o Organisatie Bureau Amsterdam BV, Europaplein, 1078 GZ Amsterdam, The Netherlands.)

ELECTRON MICROSCOPY

Summer. EUCHEM Conference on High Resolution Electron Microscopy in Solid State Chemistry. Sweden.

(Prof. L. Kihlberg, Department of Inorganic Chemistry, Arrhenius Laboratory, University of Stockholm, S-106 91 Stockholm, Sweden.)

ATOMIC SPECTROSCOPY

July. 15th Conference of the European Group for Atomic Spectroscopy. Saragossa, Spain.

(Mr. E. Bernabeu, The University E-Saragossa, Spain.)

RADIATION RESEARCH

July 3 - 8. 7th International Congress of Radiation Research. Amsterdam, The Netherlands.

(J. J. Broerse, Secretary General) 7th International Congress of Radiation Research, c/o Radiobiological Institute TNO, POB 5815, 2280 HV Rijswijk, The Netherlands.)

SOLID STATE IONICS

July 4 - 8. 4th International Conference on Solid State Ionics. Grenoble, France.

(M. Kleitz, SSI 83, ENSEEG, B.P. 44, F-38401 Saint Martin d'Heres, France.)

MONOCLONAL ANTIBODIES

July 6 - 9. International Association of Biological Standardization on Monoclonal Antibodies: Standardization in their Production and Use. Paris, France.

(Dr. M. Barme, Institut Pasteur, 25 rue du Dr. Roux, F-75015 Paris, France.)

SMOKING AND HEALTH

July 10 - 15. 5th World Conference on Smoking and Health. Winnipeg, Canada.

(5th World Conference on Smoking and Health, P.O. Box 228, Station B., Ottawa, Ontario, Canada K1P 6C4.)

PROPERTIES OF COPOLYMERS

July 11 - 14. 24th Prague Microsymposium: Copolymers, Structure and Solution Properties. Prague, Czechoslovakia.

(Dr. P. Kratochvil, c/o Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského nám. 2, 162 06 Prague 616, Czechoslovakia.)

BORON CHEMISTRY

July 11 - 15. Imeboron V (Organic and Inorganic). Swansea, Wales, UK.

(Prof. A. Pelter, Department of Chemistry, University College of Swansea, Singleton Park, Swansea, West Glamorgan SA2 8PP, UK.)

ANALYTICAL CHEMISTRY

July 17 - 23. SAC 83 Conference and Exhibition, organized by the Analytical Division of the Royal Society of Chemistry. University of Edinburgh, Edinburgh, UK.

(Dr. J. M. Ottaway, Department of Pure & Applied Chemistry, University of Strathclyde, Cathedral Street, Glasgow G1 1XL, UK.)

POLYMER STABILITY & PROCESSING

July 18 - 21. 25th Prague Microsymposium: Processing and Long-Term Stabilities of Hydrocarbon Polymers. Prague, Czechoslovakia.

(Dr. J. Pospisil, c/o Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského n. 2, 162 06 Prague 616, Czechoslovakia.)

TOXICOLOGY OF METALS

July 20 - 23. 2nd International Symposium on Clinical Chemistry and Chemical Toxicology of Metals. Montreal, Canada.

(Dr. J. Savory, University of Virginia Medical Center, Department of Pathology, Box 168, Clinical Laboratories, Charlottesville, VA 22908, USA.)

PLASMA CHEMISTRY

July 25 - 28. 6th International Symposium on Plasma Chemistry. Montreal, Canada.

(Prof. Maher Boulos, Departement de genie chimique, Faculte des sciences appliquees, Universite de Sherbrooke, Sherbrooke, Quebec J1K 2R1, Canada.)

ANALYTICAL CHEMISTRY

August. 7th Analytical Chemistry Division Symposium of the Royal Australian Chemical Institute. Adelaide, Australia.

(K. J. Heinrich, Forensic Science Centre, Divett Place, Adelaide 5000, Australia.)

CRYSTALLOGRAPHY

August. 8th European Crystallographic Meeting. Liège, Belgium.

(Prof. J. Toussaint, Institut de Physique B5, Université de Liège au Sart-Tilman, B-4000 Liège, Belgium.)

THEORETICAL CHEMISTRY

August 7 - 12. 8th Canadian Symposium on Theoretical Chemistry. Halifax, Nova Scotia, Canada.

(Dr. R. J. Boyd, Department of Chemistry, Dalhousie University, Halifax, Nova Scotia B3H 4J3, Canada.)

FOOD TOXINS

August 12 - 15. Symposium on Mycotoxins. Sydney, Australia.

(Dr. John Lacey, Department of Plant Pathology, Rothamsted Experimental Station, Harpenden, Herts AL5 2JQ, UK.)

NATURAL PRODUCTS

August 15 - 19. 2nd International Conference on Chemistry and Biotechnology of Biologically Active Natural Products. Budapest, Hungary.

(G. Kovacs, Chinoin Pharm. Che. Works H-1325 Budapest, POB 110, Hungary.)

IUPAC GENERAL ASSEMBLY

August 18 - 26. 32nd IUPAC General Assembly. Lyngby/Copenhagen, Denmark.

(IUPAC Secretariat, 2 - 3 Pound Way, Cowley Centre, Oxford OX4 3YF, UK.)

CHEMICAL EDUCATION

August 21 - 26. 7th International Conference on Chemical Education: "Chemistry Education and Society". Montpellier, France.

(Pr. M. Chastrette, Laboratoire de Chimie Organique Physique, Université Lyon I, 43, Bld du 11 Novembre 1918, 69622-Villeurbanne, France.)

HETEROCYCLIC CHEMISTRY

August 21 - 26. 9th International Congress of Heterocyclic Chemistry. Tokyo, Japan.

(Yuichi Kanaoka, Faculty of Pharmaceutical Sciences, Hokkaido University Sapporo, 060 Japan.)

SOLVENT EXTRACTION

August 26 - September 2. International Solvent Extraction Conference. Denver, CO, USA.

(ISEC '83, American Institute of Chemical Engineers, 345 East 47th Street, New York, NY 10017, USA.)

ORGANOMETALLIC CHEMISTRY

August 28 - September 1. 2nd IUPAC Symposium on Organometallic Chemistry directed toward Organic Synthesis. Dijon, France.

(Prof. J. Tirouflet, Université de Dijon, Boite Postale 138, 21004 Dijon Cedex, France.)

AMERICAN CHEMICAL SOCIETY

August 28 - September 2. 186th National Meeting of the American Chemical Society. Washington, DC, USA.

(A. T. Winstead, American Chemical Society, 1155 16th Street NW, Washington, DC 20036, USA.)

MICROCHEMICAL TECHNIQUES

August 28 - September 2. ISM '83, 9th International Symposium on Microchemical Techniques. Amsterdam, The Netherlands.

(Municipal Congress Bureau, Oudezijds Achterburgwal 199, 1012 DK Amsterdam, The Netherlands.)

TRACE ANALYSIS

August 28 - September 2. International Symposium on Microchemistry Techniques and Trace Analysis. Amsterdam, The Netherlands.

(Dr. W. J. van Oort, c/o Municipal Congress Bureau, O.Z. Achterburgwal 199, 1012 DK, Amsterdam, The Netherlands.)

FUNGI

August 28 - September 3. 3rd International Mycological Congress. Tokyo, Japan.

(Prof. K. Tubaki, Institute of Biological Sciences, University of Tsukuba, Sakura-Mura, Ibaraki 300-31, Japan.)

THERMOCHEMICAL ANALYSIS

August 28 - September 3. 3rd Seminar on Thermochemical Analysis. Czechoslovakia.

(SKODA Plzen, Development a, Specialisation Department, Mrs. I. Vostrakova, 316 00 Plzen, Czechoslovakia.)

CHROMATOGRAPHY

August 29 - September 2. 4th Danube Symposium on Chromatography and 7th International Symposium "Advances and Application of Chromatography in Industry". Bratislava, Czechoslovakia.

(Dr. Jan Remen, The Analytical Section of the Czechoslovak Scientific and Technical Society, SLOVNAFT, 823 00 Bratislava, CSSR.)

IONIZED GASES

August 29 - September 3. 16th International Conference on Phenomena in Ionized Gases. Dusseldorf, Germany.

(Dr. W. Böttcher, Institut für Plasmaphysik, Callinstr. 38, D-3000 Hannover, Federal Republic of Germany.)

29th IUPAC Congress

5-10 June 1983

Cologne, Federal Republic of Germany

Plenary Lectures

Host-Guest Complexation

D. J. Cram, University of California

Übergangsmetall-Carbin-Komplexe

E. O. Fischer, Technische Universität München

Electrochemical Conversion of Light

H. Gerischer, Fritz-Haber Institute

Treatment of Nuclear Wastes

G. Höhle, Kernforschungszentrum Karlsruhe GmbH

Stand und Zukunft der C₁-Chemie

W. Keim, Technische Hochschule Aachen

Everyone needs to know Chemistry: A Teaching Challenge

G. C. Pimentel, University of California

Anaerobic Treatment of Industrial Wastewater

H. Sahm, Kernforschungsanlage Jülich GmbH

Removal of Chemical Wastes

W. Simmler, BAYER AG

Biotechnology: Past, Present and Future

D. I. C. Wang, Massachusetts Institute of Technology

The Congress will have 5 sessions of main lectures, dealing with recent advances and progress in the following areas:

Biosynthesis of the pigments of life

Polypeptide neurotoxins

Inorganic Chemistry

Aspects of organo-phosphorus chemistry

Synthetic strategies using excited-state metal atomic and cluster reagents

The chemistry of unusually reactive intermediates

Inorganic cluster chemistry relating to biology

Macropolycyclic structures and cryptate complexes

Zintl polyanions. Homo- and heteroatomic examples

Design and synthesis of novel polyhedral metalloboranes

Catalysis with metallocarboranes

Recent advances in organometallic cluster chemistry

Multiple decker metal sandwich complexes

Designed syntheses of small metal clusters

Solid electrolytes and applications to battery problems

High pressures in preparative solid state chemistry

In vitro photosynthesis with organized molecular assemblies and colloidal semiconductors

Organic Chemistry

Regioselectivity in reactions of ambident anions and cations

Preparation of macrolides by stereospecific and regioselective transformation of carbohydrates

Transition metal mediated cycloadditions

Synthetic applications of amino acids

CATIONIC POLYMERIZATION

August 30 - September 2. 6th International Symposium on Cationic Polymerization and Related Processes. Belgium.

(Prof. E. Goethals, Institute of Organic Chemistry, Rijksuniversiteit-Ghent, Krijgslaan 281 (S-4) B-9000 Ghent, Belgium.)

ON-LINE MONITORING

August 31 - September 2. 1st International Conference on On-Line Surveillance and Monitoring ("ICOSM 83"). London, UK.

(ICOSM '83 c/o The Conference Secretariat, Society of Chemical Industry, 14/15 Belgrave Square, London SW1X 8PS, UK.)

POLYMERIZATION OF HETEROCYCLES

September. International Symposium on Polymerization of Small Heterocycles and Aldehydes. Poland.

(Polymer Institute, POB 49, Curie - Sklodowskiej 34, PL - 41 800 Zabrze, Poland.)

GEOCHEMICAL EXPLORATION

September. 10th International Geochemical Exploration Symposium. Helsinki, Finland.

(L. K. Kauranne, Organizing Committee, 10th IGES., The Geological Survey of Finland, Kivimiehentie 1, 02150 Espoo 15, Finland.)

FOURIER TRANSFORM SPECTROSCOPY

September 5 - 9. International Conference on Fourier Transform Spectroscopy. Durham, UK.

(J. R. Birch, Division of Electrical Science, National Physical Laboratory, Teddington, Middlesex TW11 0LW, UK.)

MACROMOLECULES

September 5 - 9. 29th International Symposium on Macromolecules. Bucharest, Romania.

(Acad. Cristofor Simionescu, Institutul de Chimie, Macromoleculara Petru Poni Aleea Grigore Ghica Voda Nr. 41A, Iasi, Romania.)

ORGANIC CHEMISTRY

September 5 - 9. 3rd European Symposium on Organic Chemistry. University of Kent, Canterbury, UK.

(Prof. R. F. Hudson, University of Kent at Canterbury, Kent CT2 7NH, UK.)

PHOSPHORUS CHEMISTRY

September 5 - 9. International Conference on Phosphorus Chemistry. Nice, France.

(Prof. J. G. Riess, Laboratoire de Chimie Minérale Moléculaire, Université de Nice, Parc Valrose, 06034 Nice, France.)

CRYSTAL GROWTH

September 12 - 16. 7th International Conference on Crystal Growth. Stuttgart, Federal Republic of Germany.

(Prof. Dr. M. Pilkuhn, Universität Stuttgart, Pfaffenwaldring 57, 7000 Stuttgart 80, Federal Republic of Germany.)

FOOD TECHNOLOGY

September 18 - 23. 6th World Congress of Food Science and Technology. Dublin, Ireland.

(Dr. R. L. Joseph, c/o An Foras Taluntais, Dunsinea, Castleknock, Co. Dublin, Ireland.)

Conformational control in natural products synthesis
Electron transfer reactions and their role in organic chemistry

Generation and reactivity of carbocations
Macrocyclic molecular receptors and coreceptors
Progress in the biosynthesis of natural products

Physical and Theoretical Chemistry

Synergetics — theory of nonequilibrium phase transitions

Applications of molecular quantum mechanics to problems in chemistry

Laser-induced nonlinear processes in atoms and molecules

Laser studies on reaction dynamics

Electrochemical energy conversion

Micelles and microemulsions

Ion flow through membrane pores

Supercritical fluid extraction

Chemical reactions on single crystal metal surfaces

Photoelectron spectroscopy of adsorbates

Production of Chemical Basic Materials

Neuere Entwicklungen auf dem Gebiet der alkali-Chlorid-Electrolyse

Low grade ore processing

Present status of coal gasification

Hydrocarbons via Fischer-Tropsch synthesis

Present status of coal hydrogenation

Hydrocarbon cracking and synthesis by shape selective catalysis

High level synthesis of proteins using genetic engineering approaches

Production of optically active compounds using immobilized biocatalysts

Chemicals and fuels from biomass conversions

Education in Chemistry

Chemistry on television: what should we say to whom and how?

Closed circuits — chemistry harmless for the environment

The teaching of molecular geometry using VSEPR theory

The role of experiments in the teaching of chemistry

Teaching chemistry today, what do we aim for?

Chemistry as a basis for life sciences — where did we go wrong?

Ausbildung von Technikern in den Ölfeldern der Sahara

Training for chemistry vocations in Norway

Vocational training, how to meet the needs

In addition to the plenary and main lectures, the Congress will include short (15 minute) papers and posters. There will also be a Joint Symposium on "The Chemical Information Flow: at present and in the future", and an exhibition of laboratory equipment and scientific literature.

The registration fee for the Congress will be about DM 370 (or DM 120 for students). Further information and registration forms for the 29th IUPAC Congress can be obtained from Dr. W. Fritzsche, IUPAC Congress Secretariat, c/o Gesellschaft Deutscher Chemiker, P.O. Box 90 04 40, D-6000 Frankfurt/Main 90, Federal Republic of Germany.

ENERGY RESOURCES

September 19 - 23. 12th World Energy Conference. New Delhi, India.

(E. Ruttley, World Energy Conference, 34 St. James' Street, London SW1A 1HD, UK.)

MOSSBAUER EFFECT

September 26 - 30. International Conference on the Applications of Mossbauer Effect. Alma-Ata, USSR.

(Dr. V. Ya. Rochev, Institute of Chemical Physics, Academy of Sciences of the USSR, Ulitsa Kossygina, 4, Moscow 117334, USSR.)

ENVIRONMENTAL PROTECTION

September 19 - 25. 4th International Conference on Chemistry for Environmental Protection. Toulouse, France.

(Prof. A. Verdier, Ecole Nationale Supérieure de Chimie, 118 route de Narbonne, 31077 Toulouse Cedex, France.)

SOLID - LIQUID SEPARATION

September 19 - 21. International Symposium on Advances in Solid - Liquid Separation. University College, London, UK.

(Conference Secretariat, Society of Chemical Industry, 14/15 Belgrave Square, London SW1X 8PS, UK.)

DRUG ABSORPTION

September 21 - 23. 2nd International Conference on Drug Absorption: Rate Control in Drug Therapy. Edinburgh, UK.

(Secretariat, 2nd International Conference on Drug Absorption, Centre for Industrial Consultancy and Liaison, University of Edinburgh, 16 George Square, Edinburgh EH8 9LD, UK.)

POTASH TECHNOLOGY

October 3 - 5. 1st International Potash Technology Conference. Saskatoon, Saskatchewan, Canada.

(Miss Joyce Lubenow, Conference Secretary, c/o SEDCO, 241 Second Avenue South, Saskatoon, Saskatchewan S7K 1K8, Canada.)

CORROSION PROTECTION

October 9 - 14. Joint Symposium on Fundamental Aspects of Corrosion Protection by Surface Modification. Washington, DC, USA.

(R. P. Frankenthal, Chairman, Corrosion Division of Electrochemical Society, c/o Bell Laboratories, 600 Mountain Avenue, Murray Hill, NJ 07974, USA.)

ENVIRONMENTAL BIOGEOCHEMISTRY

October 9 - 14. 6th International Symposium on Environmental Biogeochemistry. Santa Fe, New Mexico, USA.

(Douglas Caldwell, Department of Biology, University of New Mexico, Albuquerque, NM 87 131, USA.)

ORGANIC FREE RADICALS

October 16 - 21. EUCHEM Conference on Organic Free Radicals. Schloss Elmau, Federal Republic of Germany.

(Prof. R. Sustman, Universität Essen-Gesamthochschule, Universitätsstrasse 5, 4300 Essen 1, Federal Republic of Germany.)

1984

CHEM/ASIA

January. 2nd Chemical Congress of the Federation of Asian Chemical Societies. India.

(Dr. M. Singh, Rubber Research Institute of Malaysia, P.O. Box 150, Kuala Lumpur, Malaysia.)

SOLID FILMS AND SURFACES

January. 3rd International Conference on Solid Films and Surfaces. Sydney, Australia.

(Prof. D. Haneman, Department of Physics, University of NSW, Kensington, NSW 2033, Australia.)

CORROSION

April 1 - 6. Corrosion '84 International Conference. New Orleans, LA, USA.

(Conference Co-ordinator, National Association of Corrosion Engineers, POB 218340, Houston, TX 77218, USA.)

MINERAL PROCESSING

April 1 - 6. Corrosion '84 International Conference Advances in Mineral Science and Technology (MINTECH 50). Johannesburg, South Africa.

(Conference Secretariat, National Institute for Metallurgy, Private Bag X3015, 2125 Randburg, Republic of South Africa.)

EXTRACTIVE METALLURGY

April 2 - 13. International Conference on Recent Advances in Extractive Metallurgy. Johannesburg, South Africa.

(Conference Secretariat, National Institute for Metallurgy, Private Bag X3015, 2125 Randburg, Republic of South Africa.)

AMERICAN CHEMICAL SOCIETY

April 8 - 13. 187th National Meeting of the American Chemical Society. Missouri, USA.

(A. T. Winstead, American Chemical Society, 1155 16th Street NW, Washington, DC 20036, USA.)

BIOMATERIALS

April 26 - May 1. 2nd World Congress on Biomaterials. Washington, DC, USA.

(Dr. S. R. Pollack, Department of Bioengineering, 285 Town Building D3, University of Pennsylvania, Philadelphia, PA 19104, USA.)

SCIENCE/AUSTRALASIA

May. 54th Conference of the Australian and New Zealand Association for the Advancement of Science. Canberra, Australia.

(ANZAAS, Box 873, GPO Sydney 2001, Australia.)

METALLIC CORROSION

June 3 - 7. 9th International Congress on Metallic Corrosion (ICMC). Toronto Canada.

(Mrs. L. Baignée, Executive Secretary, 9th ICMC, c/o National Research Council, Ottawa K1A 0R6, Canada.)

PRECIOUS METALS

June 3 - 7. 8th International Conference on Precious Metals. Toronto, Canada.

(Int. Precious Metals Institute, Polytechnic Institute of New York, 333 Jay Street, Brooklyn, NY 11201, USA.)

CHEMRAWN II

June 25 - 29. CHEMRAWN III. Amsterdam, The Netherlands.

(Ir. E. J. de Ryck van der Gracht, Executive Secretary, Royal Netherlands Chemical Society, Burnerstraat 1, 2596 HV Den Haag, The Netherlands.)

CATALYSIS

July 2 - 6. 8th International Congress on Catalysis. Berlin, Federal Republic of Germany.

(DECHEMA, P.O. Box 970146, D-6000 Frankfurt am Main 97, Federal Republic of Germany.)

NATURAL PRODUCTS

July 9 - 14. 14th International Symposium on the Chemistry of Natural Products. Poznan, Poland.

(Prof. dr. Maciej Wiewiorowski, Institute of

Bioorganic Chemistry, Polish Academy of Sciences, ul. Noskowskiego 12/14, 61-704 Poznan, Poland.)

ION EXCHANGE

July 15 - 20. International Conference on Ion Exchange. Cambridge, UK.

(Conference Committee, IEX '84, Society of Chemical Industry, 14 Belgrave Square, London SW1X 8PS, UK.)

ORGANIC CHEMISTRY

August. 7th IUPAC Conference on Physical Organic Chemistry. Auckland, New Zealand.

(Conference Secretary, Professor B. R. Davis, Chemistry Department, University of Auckland, Private Bag, Auckland, New Zealand.)

CRYSTALLOGRAPHY

August 9 - 18. 13th General Assembly and International Congress of Crystallography. Hamburg, Federal Republic of Germany.

(Dr. J. N. King, Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, UK.)

ORGANIC SYNTHESIS

August 26 - 30. 5th International Conference on Organic Synthesis. Freiburg, Federal Republic of Germany.

(Gesellschaft Deutscher Chemiker, Postfach 90 04 40, D-6000 Frankfurt/Main 90, Federal Republic of Germany.)

AMERICAN CHEMICAL SOCIETY

August 26 - 31. 188th Meeting of the American Chemical Society. Pennsylvania, PA, USA.

(A. T. Winstead, American Chemical Society, 1155 16th Street NW, Washington, DC 20036, USA.)

RAMAN SPECTROSCOPY

August 26 - September 1. 9th International Conference on Raman Spectroscopy. Japan.

(Prof. Mitsuo Tasumi, Department of Chemistry, Faculty of Science, The University of Tokyo, Bunkyo-ku, Tokyo 113, Japan.)

HETEROCYCLES & ALDEHYDES

September. Conference on Polymers of Small Heterocycles and Aldehydes. Poland.

(Prof. Z. Jodinski, Polymer Institute, POB 49, Curie-Sklodowskiej 34, PL-41 800 Jabrze, Poland.)

FORENSIC SCIENCE

September 18 - 25. 10th Conference of the International Association of Forensic Sciences. Oxford, UK.

(Forensic Science Society, P.O. Box 41, Harrogate, N. Yorks HG1 1QL, UK.)

ENVIRONMENTAL CHEMISTRY

November 22 - 24. 14th Annual Symposium on the Analytical Chemistry of Pollutants and the 3rd Inter-

national Congress on Analytical Techniques in Environmental Chemistry. Barcelona, Spain.

(14th Annual Symposium—3rd International Congress-Expoquimia, Avda. Reina Ma. Cristina -Palacio no. 1, Barcelone 4, Spain.)

BIOTECHNOLOGY

November/December. 7th International Biotechnology Symposium. New Delhi, India.

(Prof. T. K. Ghose, Chairman, National Organisation Committee & Head, Biochemical Engineering Research Centre, Indian Institute of Technology, Hauz Khas, New Delhi-110029, India.)

AMERICIUM AND CURIUM CHEMISTRY

December 16 - 22. International Symposium on Americium and Curium Chemistry and Technology. Honolulu, Hawaii, USA.

(Dr. James D. Navratil, Rockwell International, Rocky Flats Plant, P.O. Box 464, Golden, CO 80401, USA.)

CHEMISTRY/PACIFIC BASIN

December 16 - 22. International Congress of Pacific Basin Societies. Honolulu, Hawaii.

(A. T. Winstead, ACS, 1155 16th St. NW, Washington, DC 20036, USA.)

1985

POLYMERS

February 11 - 14. POLYMER 85—Characterization and Analysis of Polymers. Melbourne, Australia.

(Dr. James H. O'Donnell, Polymer & Radiation Group, Department of Chemistry, University of Queensland, Brisbane 4067, Australia.)

CORROSION

March 25 - 29. Corrosion '85 International Conference. Boston, MA, USA.

(Conference Co-ordinator, National Association of Corrosion Engineers, POB 218340, Houston, TX 77218, USA.)

BIO-ENGINEERING

July 7 - 13. 14th International Conference on Medical and Biological Engineering and 7th International Conference on Medical Physics. Helsinki, Finland.

(Dr. N. Saranummi, Finnish Society for Medical Physics and Medical Engineering, P.O. Box 27, 33231 Tampere 23, Finland.)

CHEMICAL RESOURCES OF THE OCEAN

September 22 - 28. CHEMRAWN IV—Chemistry and Resources of the Oceans. MA, USA.

(J. Robert Moore, Director, Marine Science Institute, The University of Texas, Austin, TX 78712, USA.)

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The International Union of Pure and Applied Chemistry (IUPAC), formed in 1919, is a voluntary, non-governmental, non-profit association of organizations, each of which represents the chemists of a member country. Its objectives are:

to promote continuing co-operation among the chemists of the member countries;

to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;

to co-operate with other international organizations which deal with topics of a chemical nature;

to contribute to the advancement of pure and applied chemistry in all its aspects.

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Cover: The surface analysis instrument at the University of Queensland will perform a range of surface analysis techniques, serving the needs of chemical researchers in Brisbane, Australia. The instrument can identify atoms present on a surface by bombarding the sample with argon ions. Secondary ions ejected from the surface are analyzed by a mass spectrometer. Eventually, the capability of the instrument will be expanded to include two other surface analysis methods: X-ray photoelectron spectroscopy and Auger electron spectroscopy. Here, the Editor tries his hand at the instrument console.

